



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Special Issue 2, December 2021

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.569

Impartial Routing for Overlapped Cooperative Heterogeneous Wireless Sensor Networks

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ABSTRACT: In recent years, as wireless sensor networks (WSNs) are widely diffused, various covering WSNs developed on an identical region become more normal. In such a circumstance, their lifetime is anticipated to be reached out by helpful bundle sending. Albeit a few analysts have learned with regards to participation in various WSNs, the vast majority of them don't consider the heterogeneity within the characteristics of every WSN like battery capacity, operation start time, the amount of nodes, nodes locations, energy consumption, packet size and/or data transmission timing, and so on. In a heterogeneous climate, guileless lifetime improvement with collaboration probably won't be fair. In this paper, we propose a reasonable helpful steering technique for heterogeneous covered WSNs. It introduces an energy pool to take care of the entire amount of energy consumption by cooperative forwarding. The energy pool plays a task of broker for fair cooperation. Finally, simulation results show the superb performance of the proposed method.

KEYWORDS: Sensor network, cooperative routing, fairness, heterogeneous environment, loads balancing.

I. INTRODUCTION

RECENTLY, wireless sensor networks (WSNs) have gotten a lot of consideration as a way for gathering and using information from world. The number of WSN applications has been increasing widely and therefore the application range is expected to spread [1], [2].

A WSN may be a network composed of an outsized number of sensor nodes with limited radio capabilities and one or a couple of sinks that collect data from sensor nodes. For the most part, sensor hubs are controlled by little batteries, henceforth, the energy utilization in working a WSN ought to be pretty much as low as could be expected. A few strategies for drawing out network lifetime are needed in WSNs [1]–[3].

Although all sensor nodes generate an equal amount of knowledge packets during a WSN, nodes around a sink need to relay more packets and have a tendency to die before other nodes because the energy consumption of sensor nodes is almost completely dominated by data communication rather than by sensing and processing. Subsequently, the entire organization lifetime can be delayed by adjusting the correspondence load at intensely stacked hubs around a sink [4]. This issue is known as the energy opening issue [5], [6] and is one of the main issues for WSNs. There are various examinations about load adjusting for WSNs like clustering [7].

In addition, as WSNs are diffused widely, various over-lapping WSNs built on an identical region become more normal. In such a circumstance, participation among the WSNs to delay network lifetime has been considered [8]–[10]. Assuming that every sink of WSNs features a different location, the heavily loaded area is additionally different. In this case, cooperation of multiple WSNs could also be ready to improve the network lifetime of every WSN by load balancing everywhere the WSNs [11]–[13].

Note that even during a case where multiple WSNs are constructed at an equivalent place, they operate their applications independently and that they have heterogeneous characteristic features. In any case, a large portion of the current investigations don't think about this issue. For instance, if battery capabilities of sensor nodes in each network

are different, so as to cooperate during a profitable way, we'd like to think about some parameters, such as their energy utilization rate, not just their leftover battery. Something else, it's conceivable that specific WSNs draw out their lifetime however others abbreviate their lifetime. Since their applications are different, data sending span or potentially bundle size might be additionally unique. Hence, for fair cooperation, it's necessary to think about the entire number of times that the node have forwarded a packet, rather than that specialize in each packet forwarding only. Furthermore, operation start time, the amount of nodes and/or sensing area of every network could also be also different.

In this paper, we think about the heterogeneity of organizations and propose a decent helpful steering technique, to avoid unfair improvement only on certain networks. We introduce one or a couple of shared nodes which will use multiple channels to relay data packets. Expecting that sinks and shared hubs can speak with any WSNs here, various WSNs can utilize helpful directing with each other since shared hubs permit sensor hubs to forward data from one more WSN considering the way that the limit of trade centers among specific WSN planes.

While getting a bundle, a common hub chooses the course to send the parcel, steady with proposed course determination techniques. This collaboration draws out the lifetime of each organization similarly as could really be expected.

II. RELATED WORK

A. Traditional Approach for Longer Lifetime

Clustering [7] is one among the foremost famous methods due to its good scalability and therefore the support for data aggregation. Data aggregation consolidates information bundles from various sensor hubs into one information parcel by taking out repetitive data. This diminishes the transmission load and the aggregate sum of information. In clustering, the energy load is even by unique appointment of group heads (CHs) [14]. By rotating the CH role among all sensor nodes, each node tends to expend an equivalent amount of energy over time. All things considered, as with common multi bounce sending, a CH around a sink will in general have higher traffic than other CHs. As a result, nodes around sinks die before other nodes, even in clustered WSN [15].

In general, one WSN features a single sink. The amount of traffic increases round the sink, therefore nodes round the sink tend to die earlier. This is called energy whole problem. Also, in an enormous scope WSN with countless sensor hubs, the energy opening issue is more genuine. Then, some researchers have proposed construction methods of multiple-sink networks [16], [17]. In a multiple-sink WSN, sensor nodes are divided into a couple of clusters. Sensor nodes within a cluster are connected with one sink, which belongs thereto cluster. In contrast to a single-sink WSN, during which nodes round the sink need to relay data from most nodes, nodes around each sink relay smaller amount of knowledge only from nodes that are in the same cluster. Accordingly, the correspondence heap of hubs around sinks is frequently diminished. However, there are some problems like the way to determine the optimal location of every sink and therefore the optimal number of sink.

B. Cooperation between Multiple WSNs

In existing investigations, most explores accept that a solitary organization is conveyed by a solitary expert in the detecting region. Be that as it may, as WSNs get used all the more broadly, numerous WSNs will in general be conveyed inside a similar region. For instance, in the UK, some different networks of cameras by different authorities like police, highway patrol, and native city authorities are deployed on an equivalent road [18]. As of late, a few specialists have proposed the participation technique for various WSNs in such circumstances.

At the point when the worth gets higher, the result of an organization gets lower. In [11], the expected advantages of participation in numerous WSNs are explored. The creators figured the framework model with target work and a bunch of issue limitations. Then, a applied mathematics framework is employed to unravel the optimization problem. Since their goal is to research the utmost achievable sensor network lifetime with different multi-domain cooperation strategies, optimization objective is network lifetime, which is defined because the time when the first sensor node during a network exhausts its battery and dies. The authors additionally researched the collaboration in various organizations that are conveyed marginally unique area [12].

Some researchers have addressed the cooperation problem with employing a game-theoretic framework [20], [21]. It is accepted that a WSN highlights a judicious and childish person and can possibly help out another organization if this affiliation offers types of assistance that legitimize the participation.

Virtual Cooperation Bond (VCB) Protocol [20] is one among the game-hypothetical methodologies. It is a distributed protocol that makes various organizations to collaborate, if and just if every one of the organizations acquire a few advantages by the participation. The authors figured the participation issue among various WSNs as a helpful game in principle of games. In VCB protocol, the energy consumption of knowledge communication is employed as costs. When the value gets higher, the payoff of a network gets lower than no cooperation scenario. The reproduction results showed that the VCB can save transmission energy somewhere in the range of 20% and 30% during a specific climate.

C. Problematic Issues

Discussed above, we assume that multiple WSNs are deployed by different authorities within the same area. Those WSNs operate different applications independently, hence, they need heterogeneous characteristics, like battery capacity, operation start time, the amount of nodes, nodes locations, energy consumption, packet size and/or data transmission timing. However, most existing participation techniques don't believe this heterogeneity. For instance, when batteries capacities on sensor nodes are quite different by a WSN, a cooperative routing method supported residual energy isn't appropriate since a WSN which has the utmost battery capacity always forwards packets from other WSNs. As a result, although certain WSNs prolong their lifetime, the opposite WSNs may shorten their lifetime. In such a situation, fairness of cooperation may be a highly important issue. In this paper, we aim to enhance all WSNs lifetime by fair cooperative routing during a heterogeneous environment, avoiding improving the lifetime of only certain WSNs.

III. PROPOSED METHOD

Assumed Environment

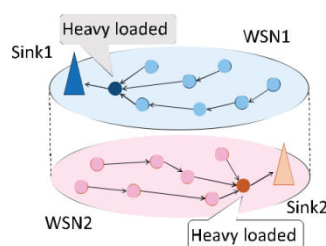


Fig1 Two WSNs deployed at the same area.

In this paper, we assume the subsequent environment. In a detecting field, m distinctive WSNs are developed, and various applications are working on each WSN independently. Figure 1 show a model where two WSNs are built. In the event that substantial stacked hubs are in a few spots among the WSNs as shown inside the model, it's conceivable that information parcels by means of weighty stacked hubs are sent by other. However, each network adopts different channel, hence sensor nodes are unable to communicate with a node belonging to a different WSN. To conquer this restriction, q shared hubs, which are top of the line hubs with multi-channel correspondence unit, are conveyed nearby. Shared nodes and sinks are ready to communicate with any nodes belonging to all or any WSNs. Sensor nodes consume their energy only by communication, which may be a reasonable assumption in sensor networks with simple sensors. Sinks and shared hubs have adequately huge batteries or force supply. We define the WSNs' lifetime because the time when a primary sensor node depletes its all battery energy.

For heterogeneity, the battery capacity of a sensor node, the amount of nodes, nodes' locations, energy consumption by communication, packet size, data transmission timing and

A System Model

WSNs $N_1, \dots, N_m$ are constructed, and every network N_i , $1 \leq i \leq m$, features a set of unique sensor nodes $N_i = \{ni_1, ni_2, \dots, ni_{|N_i|}\}$ and $|WSNs N_1, \dots, N_m|$ are constructed, and every network N_i , $1 \leq i \leq m$, features a set of unique sensor nodes $N_i = \{ni_1, ni_2, \dots, ni_{|N_i|}\}$ and $|WSNs N_1, \dots, N_m|$ are constructed, and every network N_i , $1 \leq i \leq m$, features a set of unique sensor nodes

$N_i = \{ni_1, ni_2, \dots, ni_{|N_i|}\}$ and the sink BS_i . q shared nodes $s_1, \dots, s_q$ also exists within the area. All WSNs are ready to use these shared nodes as relay node for packet forwarding. For guaranteeing the lifetime improvement by the cooperation, we define network lifetime L_i , the estimated lifetime of WSNs $N_1, \dots, N_m$ are constructed, and every

network N_i , $1 \leq i \leq m$, features a set of unique sensor nodes $N_i = \{ni_1, ni_2, \dots, ni_{|N_i|}\}$ and, is obtained by Eq. (1). $L_i = \min_{n_{ij} \in WSNs} N_1, \dots, N_m$ are constructed, and every network N_i , $1 \leq i \leq m$, features a set of unique sensor nodes $N_i = \{ni_1, ni_2, \dots, ni_{|N_i|}\}$ and L_{ij} ($1 \leq j \leq |N_i|$). (1)

L_{ij} is that the assessed lifetime of the sensor hub n_{ij} here. We call it node lifetime. In other words, the estimated lifetime of a WSN may be a minimum estimated lifetime of its all sensor nodes.

Every sensor hub estimates its own energy utilization during explicit time τ and ascertains L_{ij} by utilizing it. Let e_{ijt} be the excess energy of hub n_{ij} at time t , then, at that point, energy utilization per unit time is depicted by $e_{ijt} - e_{ij}(t+\tau) / \tau$, (2) and L_{ij} is addressed by Eq. (3).

$L_{ij} = e_{ijt}(t+\tau) \cdot \tau / (e_{ijt} - e_{ij}(t+\tau))$ (3) by exchanging L_{ij} periodically among neighboring nodes, each node updates L_i . In addition, minimum lifetime L_0 , the estimated lifetime in the case of no cooperation, is calculated by each sensor node. In particular, each WSN works with no collaboration from time $t = 0$ to $t = 0 + \tau = \tau$, and after the span, L_0 is determined. Specific updating procedure of L_i and L_0 is explained in Sect. 3.4. A shared node sk ($1 \leq k \leq q$), has m routes $R_{i,kl}$ to the sink BS_i via network N_i ($1 \leq i \leq m$). Hence, sk selects one of the m routes when sk receives a data packet from network WSNs $N_1, \dots, N_m$ are constructed, and every network N_i , $1 \leq i \leq m$, features a set of unique sensor nodes $N_i = \{ni_1, ni_2, \dots, ni_{|N_i|}\}$ and. If $i = 1$, WSNs $N_1, \dots, N_m$ are constructed, and every network N_i , $1 \leq i \leq m$, features a set of unique sensor nodes $N_i = \{ni_1, ni_2, \dots, ni_{|N_i|}\}$ and rents the energy resource from N_1 . Moreover, we define route lifetime $L_{R_{i,kl}}$ as the estimated lifetime of the route $R_{i,kl}$. The detailed definition is as follows.

$L_{R_{i,kl}} = \min_{n_{ij} \in R_{i,kl}} L_{ij}$ (5) Eq. (5) implies that $L_{R_{i,kl}}$ is the base lifetime among the hubs being contained in course $R_{i,kl}$.

A. Route Discovery

Each sensor node creates its routing table supported a routing protocol. In this paper, we used unplanned on-demand distance vector (AODV) [19] as a routing protocol, because AODV was developed for wireless unplanned networks and was adopted for some WSN protocols like Zigbee [22] and ANT [23]. In course disclosure, every sensor hub finds its courses not exclusively to the sink in its WSN yet in addition to all or any the contrary sinks inside the unique.

WSNs for freedoms to advance information parcels from hubs in various WSNs to their sink. Therefore, the routing table of every sensor node has m routes like each sink altogether WSNs. A common hub makes m courses by means of m diverse WSNs to a sink. A common hub makes m courses by means of m diverse WSNs to a sink.. There are m sinks, in total, like m WSNs. In this manner, a common hub has $m \times m$ routes. Therefore, a common hub has $m \times m$ courses. In AODV course disclosure, every hub picks a course that has the base number of bounces to the sink. However, the proposed method uses not the amount of hops but a price calculated by simple accumulation, in order that more routes are established via shared nodes. This is because different WSNs are often used only via shared nodes as alternative routes. In particular, we set 1 as the expense of going through a sensor hub and we set x ($0 < x < 1$) as the expense of going through a common hub. At the point when every hub finds a course, it picks a course that has the base expense determined on the grounds that the amount of navigating hubs.

D Obtaining Lifetime Information

For cooperation considering the fairness among multiple WSNs, shared node sk maintains estimated lifetime information, network lifetime L_i , minimum lifetime L_0 and route lifetime $L_{R_{i,kl}}$. We explain how to obtain this information as follows. At the time of transmitting a data packet, sensor node n_{ij} adds the values of its network lifetime L_i and route lifetime $L_{R_{i,kl}}$ to the MAC frame header of the packet. If the node does not have any information on network lifetime or route lifetime yet, for instance at the time immediately after creating or updating the route, its own node lifetime L_{ij} is added alternatively. Each node updates this information by

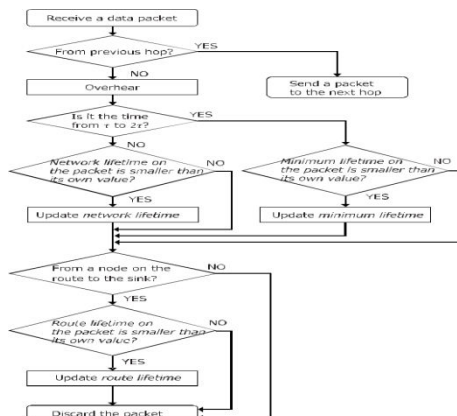


Fig. 2. Obtaining lifetime information.

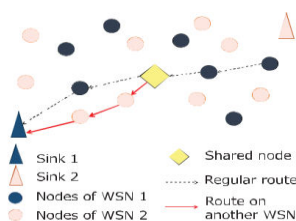


Fig.3. Example of the cooperative routing with a Shared node in

Overhearing data packets from other nodes. Specifically, when node n_{ij} overhears a data packet, it compares the value of the network lifetime in the data packet and L_i in its own information, and updates its own L_i to the smaller value between them. In addition, if the packet is from a node which is contained in $R_{i j_i}$, the route from n_{ij} to BS_i , it checks the value of route lifetime in the packet header, and updates its route lifetime by the smaller value as in the case of updating L_i . After that, the overhearing node discards the packet immediately if the destination of the packet is not itself. As we mentioned in Section 3.2, network lifetime for the time 0 to τ is represented as minimum lifetime L_0 . To obtain this value, each node updates its minimum lifetime with the value of network lifetime on an overheard packet, from the time τ to 2τ . Figure 2 describes this mechanism to obtain lifetime information.

E. Cooperative Data Forwarding

Since a sensor node has a single route toward the sink in its WSN, it forwards a data packet immediately to the next node on the route. On the other hand, a shared node s_k has m routes for the sink via m networks, therefore it can choose an appropriate route for data forwarding. Since the lifetime of WSN depends on the lifetime of the energy-bottleneck nodes in the WSN, cooperative data packet forwarding via alternative nodes belonging to another WSN instead of the bottleneck nodes is expected to improve the Fig. 3. Example of the cooperative routing with a shared node in two WSNs. lifetime of the WSN. An example is described in Figure 3. Here, the sensor nodes of WSN 2 between the shared node and sink 1 can forward data packets to sink 1 for WSN 1 as an alternative route on another WSN.

However, if the alternative nodes are also bottleneck of their WSN, the lifetime of their WSN would be shortened. To avoid this result, a shared node is able to choose the alternative route only if the alternative nodes are not bottleneck. That is, the condition that packet forwarding from the shared node s_k to the sink BS_i in WSN i via route $R_{i k_l}$ of WSN i is available can be formulated as follows. $L_{R_{i k_l}} > L_0$ (6) By this condition, lifetime reduction of each WSN by forwarding packets from other WSNs is avoided, and the improvement of WSNs lifetime is guaranteed. As explained in Section 3.3, a shared node has multiple routes to the sink, hence an algorithm to select an appropriate route is needed. We propose fair cooperative methods with two route selecting algorithms. The first one is named Pool-based selecting. We resemble the cooperative forwarding to debt of energy resource. Shared nodes maintain the Energy Pool, the total amount of energy consumption used by cooperative forwarding, continuously. When a node n_{lj} in N_l forwards a packet from another network N_u , the Energy-Pool of N_l is increased and that of N_u is decreased. By selecting a route

based on the value of Energy-Pool, the cooperation with the fairness of energy consumption is achieved in a heterogeneous environment. In addition, this method is able to balance the energy consumption by cooperation even if each WSN starts to operate from different time. When a shared node s_k receives a data packet, if it has multiple available routes to the sink, it compares the Energy Pool P_i of each network N_i , and selects the route that has minimum P_i . Let $R_{i\ k\ v}$ denote the selected route from shared node s_k to sink B_{Si} via N_v . P_v , the Energy-Pool of the network N_v which the $R_{i\ k\ v}$ belongs to is increased, and P_i , the Energy Pool of the network N_i which the source node belongs to is decreased. The amount of increase and decrease P is the energy consumption by packet forwarding from s_k to B_{Si} . It is obtained by Eq. (7).

$$P = hR_{i\ k\ v} (E_{rv} + E_{tv}) \quad (7)$$

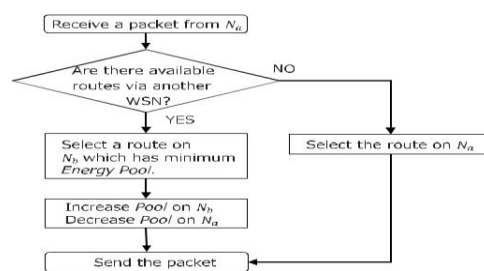


Fig. 4. Pool-based route selection.

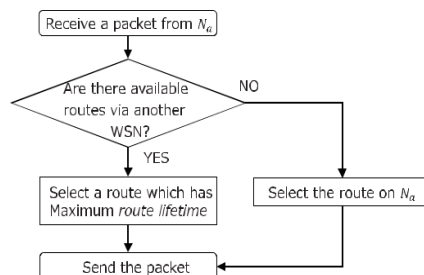


Fig. 5. Life-based routes

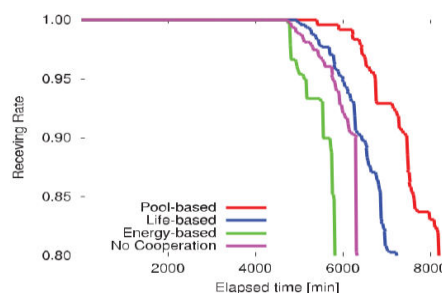


fig. 6.Receiving rate on WSN 1.

$hR_{i\ k\ v}$ is the hop count on $R_{i\ k\ v}$. E_{rv} and E_t are reception and transmission energy cost per a packet on N_v , respectively. Figure 4 shows the flow chart on Pool-based route selection at the time when a shared node s_k receives a data packet from N_a . The other is named Life-based selecting, that selects the route with maximum route lifetime. In contrast to the Energy based route selection that considers only remaining energy on the nodes, Life-based is focusing on the traffic loads by estimating the route lifetime. Therefore, it is expected that the heavy-loaded nodes balance their

loads to other network nodes and it leads to a longer lifetime. Figure 5 shows the procedure of the Life-based route selection.

IV. CONCLUSION

In this paper, we zeroed in on heterogeneous covered sensor networks that were developed at an identical region. In such a circumstance, it is normal that the lifetime, all things considered, ought to be reached out by participation in different networks. However, since the overall strategies don't think about the heterogeneity in each organization, decency as far as lifetime improvement is required.

We proposed a reasonable agreeable steering strategy with shared hubs, with the expect to accomplish reasonable lifetime improvement in heterogeneous covered sensor organizations. Reproduction results showed that the proposed technique broadened the organization lifetime.

Specifically, Pool-based collaboration accomplished minuscule difference of lifetime improvement, that is, it given very reasonable participation. As a future work, we attempt to Implement the proposed method on an experimental system and evaluate its feasibility.

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