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A novel and optimized computational framework for energy efficient data dissemination in wireless sensor network

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ABSTRACT

Wireless sensor network (WSN) is an integral part of internet-of-things (IoT), where a large scale of data transmission and various complex services are identified to be delivered. In order to facilitate these services, energy efficiency is one critical demand for resource-constraint sensor nodes. Carrier sense multiple access (CSMA) has been considered for effective traffic management for high-end data delivery services. A review of existing literature on CSMA-based schemes shows that it has not yet achieved an optimal case of energy efficiency. Hence, the proposed study presents a novel computational framework in order to address this research gap. The prime contribution of the proposed study is towards presenting an optimal computational model for maximized fairness in data dissemination services in WSN especially focusing on energy efficiency. The presented study model also contributes towards optimizing route buffer and buffer power, which facilitates towards availability of energy-efficient path information. The study also introduces a mobile auxiliary node that aggregates the data from sensor nodes and delivers it to the sink node considering dynamic location updates for seamless transmission. Scripted in MATLAB, the proposed scheme exhibited 70% energy saving compared to conventional schemes of CSMA in WSN.

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1. INTRODUCTION

Carrier sense multiple access (CSMA) is one of the mechanisms to facilitate energy-efficient data transmission in wireless sensor networks (WSN), which are characterized by resource-constraint sensor nodes [1]. As WSN-based application is usually applied in areas that do not demand human intervention, it is essential to achieve a higher network lifespan [2]. The role of CSMA comes into existence in WSN when the data fusion and aggregation process is carried out using single or multiple hops [3]. Although there are clustering schemes to offer an organized data transmission with energy efficiency in WSN [4]–[8], they have their own challenges in complex and large networks. Similarly, there are multiple energy-efficient schemes in WSN. However, most of them suffer from certain pitfalls, and hence energy in data delivery on WSN is still an active concern in research [9], [10]. The prime reason for adopting the CSMA scheme is its capability to identify an event of collision in less time while it is also reported to generate less network overhead score [11]. However, there are also associated challenges towards its practical implementation process where accomplishing scalability with CSMA is a complex problem in WSN while performing the route discovery process (especially during broadcasting). Apart from this, many existing studies have also been noticed to witness the higher time of algorithm execution, which also eventually led to higher power consumption [12].

Therefore, this leads to an open-ended question about the applicability of CSMA to offer higher energy efficiency for WSNs, whose adoption is progressively increasing in the commercial application and research sector. For this purpose, various existing methodologies and techniques have been reviewed.

Most recently, various degrees of study models have evolved to emphasize using the CSMA scheme to improve network performance. The recent work carried out by Olatinwo *et al.* [13] has integrated Time division multiple access (TDMA) with the CSMA/collision avoidance (CA) scheme to enhance the energy efficiency of biosensors. The study presents a unique scheduling approach considering the duty cycle towards on-demand Usage of sensors for mitigating collision in energy efficient manner. The adoption of the CSMA/CA scheme was also reported in the work of Zhu *et al.* [14], targeting energy optimization in sensor networks along with enhanced utilization of communication channels. Nguyen and Oh [15] have used a learning approach over CSMA/CA scheme considering sensor networks for improving contention and transmission with low complexity. Xiang *et al.* [16] have presented a cross-layer-based approach towards improving the performance of the CSMA scheme with notification of collision considering the Internet-of-Things (IoT) environment. The study shows that the performance of the CSMA scheme can be improved by considering the metrics of carrier sensing and its outage probability.

Klapez *et al.* [17] have presented a scheme for mitigating the hidden terminal problem considering vehicle communication to infrastructure. A synchronization method that shifts the packet transmission time to avoid destructive interference is presented. An inherent hidden node problem is reportedly addressed in the work of Liu *et al.* [18], where a thresholding-based scheme is formulated in the full duplex access system in CSMA. The study shows that a better energy efficiency scheme can be achieved using a complete duplex scheme in contrast to CSMA's conventional half-duplex scheme. A similar principle of adoption of a complete duplex scheme is also carried out by Kim *et al.* [19], where the mode of transmission is determined considering coding and modulation scheme. The study model presented by Cordeschi *et al.* [11] has presented a CSMA scheme with delay control to offer an increased access probability. According to this model, there is no adaptive tuning dependency to accomplish an optimized performance. The investigation carried out by Baiocchi and Turcanu [20] presented a CSMA model to compute the metric of the age of information related to message broadcasting in a single-hop network. Singh and Kumar [21] have developed a unique scheduling scheme using adaptive CSMA emphasizing networks with multi-hops. According to the study, the authors state that it is possible to improve throughput by modifying CSMA policy toward scheduling and routing.

A unique analysis associated with the usage of CSMA and Aloha has been carried out by Gao *et al.* [22], where these two random access policies are characterized. The learning outcome of the study points towards the pitfall of CSMA over Aloha. Deng *et al.* [23] also studied similar adoption of this random-access policy using comparative analysis using a learning-based approach towards approximation. The study was analyzed using the Markov chain over delay constraints to show that Aloha outperforms CSMA. At present, there are various studies focusing on energy efficiency. Various schemes of radio scheduling have also been noted towards contributing energy-efficient data transmission in WSN, as noted in the work of Mathew and Jones [24]. Shanthi and Prasanna [25] have used a genetic algorithm for routing in WSNs with higher energy efficiency. Gowda *et al.* [26] have presented a medium access control (MAC) based hybrid scheme emphasizing transmission efficiency. At the same time, the usage of multiple access of non-orthogonal type is investigated in the work of Darus *et al.* [27]. Kim and Kim also studied a similar study towards non-orthogonal multiple access [28], which redefines the CSMA scheme to offer better spectral efficiency with increasing node density.

The work carried out by Miskowicz [29] has presented a stochastic approach toward addressing the pitfall of the CSMA scheme associated with unfairness in accessing local operating networks. The evaluation of the study significantly showcases the potential problem associated with CSMA usage over a medium to an extensive range of networks. A study on the usage of medium access control protocols has been carried out by Khisa and Moh [30] considering the use case of unmanned aerial vehicles, which states that conventional MAC schemes still bear open end challenges. The problem associated with higher energy consumption in CSMA was reportedly addressed in the work of Kovvali and Sundaram [31], where a cooperative communication strategy was introduced for optimally leveraging energy transfer. The study outcome has exhibited lower latency and higher charge throughput in devices. Energy problems of CSMA were also investigated by Cheour *et al.* [32], where dynamic management of power has been formulated using frequency and voltage scaling. The study model is reported to resist higher energy consumption, thereby introducing an optimization scheme of power utilization in WSN. Rajawat *et al.* [33] have presented a scheme for energy conservation in healthcare sector applications in WSN where deep neural network and artificial intelligence has been used to identify the higher and lower score of possible energy consumption in challenging communication environments. An experimental study by Dhabliya *et al.* [34] investigated the performance of multiple energy optimization methods most frequently adopted in WSNs. The study outcome states that a cross-layer-based scheme performs better optimization toward enhancing energy conservation than all existing energy optimization schemes based on homogeneous WSN. Cortes-Leal [35] has addressed the problems of the CSMA scheme towards traffic management, too, and presented a parametric analysis towards identifying critical bottleneck conditions in WSN from the perspective of industrial applications. The study outcome states that adopting a cooperative scheme in WSN offers better traffic management irrespective of node density. Further, there are studies towards improving the overall performance of data transmission operation in WSN viz. adoption of distributed coordinated function (Abdel-Ameer *et al.* [36]), IoT-based data transmission with reliability (Hammood *et al.* [37]), swarm-intelligence based supportability (Altmemi and Yaseen [38]), adoption of neural network in motes (Mispan *et al.* [39]), congestion scheme with data transmission (Shukur [40]), public key encryption usage (Mohamad *et al.* [41]), clustering routing scheme (Alnajdi and Bajaber [42]), effect of fading in communication (Jadhav *et al.* [43]).

After reviewing the research mentioned above, various challenges have been identified in the proposed investigation. i) recent studies on CSMA are relatively less exclusively in WSN environment, although it has been used in various scattered use-cases of different forms of the network system; ii) existing studies on CSMA do not emphasize addressing energy-efficient routing process considering the dynamic or heterogeneous environment of WSN, and hence their claims of energy efficiency are less reliable over the practical ecosystem of WSN or any of its futuristic application, iii) majority of the existing literature has introduced highly sophisticated cases where more preference is given for avoidance and less for detection in CSMA, and iv) there is no report of any benchmark study model where energy efficiency is proven in peak traffic condition in WSN. The motivation of the proposed study is also drawn from existing schemes where generic modeling of CSMA has been carried out, and a learning outcome is obtained to show that an amendment carried out on conventional CSMA is more likely to offer higher energy conservation performance in WSN. However, no such reported study model proves this fact with any novel framework. Therefore, the proposed scheme presents a simplified computational model with an alternative CSMA scheme solution. The proposed study model contributes towards an enhanced energy efficiency routing scheme considering the dynamic location update. Further, the overhead and scalability are potentially controlled by introducing an auxiliary node that assists in disseminating data in peak traffic conditions.

2. METHOD

The prime purpose of the proposed method is to develop a novel and simplified framework capable of offering a higher degree of fairness in data delivery in an energy efficient manner in WSN. This implementation aims to address the possible issues during data transmission in peak traffic, which can reduce resource consumption by addressing the challenges encountered during CSMA implementation in WSN. The architecture of the proposed scheme is Figure 1 highlights the proposed model architecture, where it can be noted that various blocks of operation are included in the optimization of the framework.

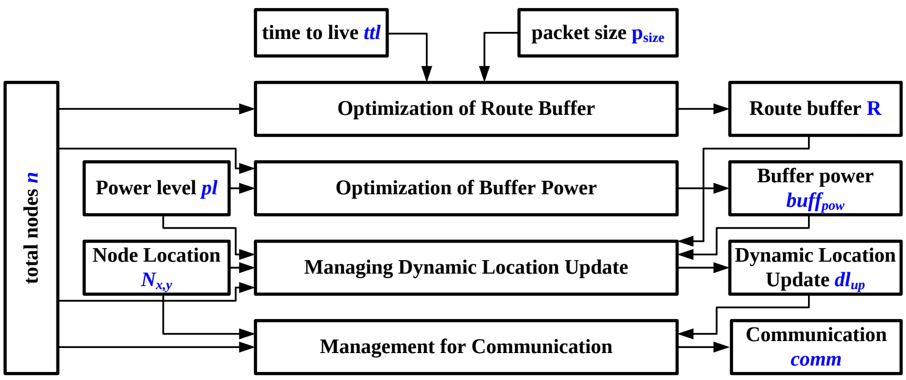

Figure 1. The architecture of the proposed method

The operation carried out by each block is progressive, taking a specific set of inputs (time to live of beacon, packet size, the power level of the node, node location, and several nodes), which is subjected to a series of block operations yield multiple outcomes where each outcome acts as an input for its consecutive block of operation. This method finally leads to communication enabled between participating sensor nodes in energy efficient and optimized manner. The step-by-step description of the proposed method is as follows:

- The sensors nodes are deployed randomly in an assigned simulation area with the presence of a base station. It will eventually mean that all the information associated with the sensors is mainly associated with location information, energy, and buffer. can be accessed from the base-station directly for all the sensors.
- The location information as well as power level associated with each sensor are accessed in order to meet the optimization objectives of the proposed scheme. This is the primary step to address the identified research problem associated with less usage of CSMA in WSN environment. The consequence of this operational step leads to generation of new communication links without data loss.
- As the proposed scheme targets optimizing the resources, the presented scheme initially performs optimization of route buffers, which a form of a memory retaining information about time to live and size of packet. An algorithm is designed which generates the final route buffer. One of the essential contributory outcomes of these steps is towards controlling a significant level of network overhead.
- The next part of operation is associated with optimization of buffer power in order to address the issues pertaining towards lack of emphasis towards energy efficient routing by CSMA. A new algorithm is designed which takes power and location information as an input to generate final outcome of computed buffer power to be used. This is one of the significant novelties where resources are computed dynamically in WSN in contrast to existing CSMA schemes with static allocations.
- After the computation of route buffer and buffer power is accomplished, the next task is towards managing dynamic location update. The prime contribution and novelty of this method is towards computation of an optimal route on the basis of dynamic location that are more sustainable to real-world sensor applications. A new role of sensor called auxiliary node is introduced which assists in data delivery to the mobile sink. An algorithm is constructed that generates computed values of dynamic location update. Adoption of these steps lead to sustainable data delivery ratio in presence of available sensors.
- In the last stage of this method, all the prior outcomes i.e., computed value of route buffer, buffer power, and dynamic location update are utilized in order to perform data dissemination operation in WSN. The novelty and contribution of this method step is that it can offer sustainable management towards peak traffic condition in WSN. The overall consequences of these methodological steps are enhanced data transmission characterized by low energy consumption compared to existing schemes.

The illustrative discussion of each operation block is carried out further to understand the proposed scheme.

2.1. Optimization of route buffers

The prime agenda of this operation is to construct a route buffer, a form of matrix accumulated from the path to be used for exploration in performing routing in WSN based on its available power. The prime contribution of the formation of route buffers is that it facilitates enhanced route exploration during peak traffic conditions. The implementation steps for this operation are given in Algorithm 1.

Algorithm 1. Optimizing route buffers

```
Input: n, ttl, p_size
Output: R
Start
1. For i=1:n
2.      [n_x, n_y]=f_1(n, l, w)
3.      If K∈P
4.          K=r_int(c)
5.      Else
6.          ttl_set=1
7.       End
8.      R_idx=f_2(length(s_st(p_size)))
9.      R[ottl, c_hop, l_up]=[P, K, ()];
End
```

The algorithm takes the input of n (total nodes), *ttl* (time to live), and p_{size} (packet size), which after processing, yields an outcome of R (route buffer). The initial point of implementation of the proposed algorithm is to apply a function f_1(x) to construct a node to be deployed in the simulation area considering total nodes n, length l, and width w of the simulation area. The function generates its outcome arguments in the sensor node's location, i.e., (n_x, n_y) (Line-2). In the pre-deployment state, the algorithm checks whether the variable K is a part of P, where K and P are integer numbers and source selection time considering the available size of power p_{size}, respectively (Line-3). Within this conditional logic (Line-3), the certain constant number (say 1,000) is opted using r_{int} method responsible for generating a random integer and allocates back the value to variable K (Line-4). Otherwise (Line-5), the algorithm sets the time to live for the beacon ttl_{set} as 1 (Line-6). Further, the algorithm implements a function f_2(x) which evaluates the length of source selection time s_{st} with respect to p_{size}, and the final value is considered as a random identity of a node, i.e., R_{idx} (Line-8). Further, a data structure R is constructed for all sensor nodes n, which retains information about optimized time to live *ottl*, common hop c_{hop}, and location update of sensor l_{up} (Line-9). This metric of data structure R represents the route buffer which retains information about optimized routes on the basis of the power levels of sensor nodes.

2.2. Optimization of buffer power

The proposed scheme considers a scheme of buffer power, which is basically an internal power-supply component that can be utilized for allocating necessary power for fulfilling the routing demands without affecting its network lifetime. This operation contributes towards overcoming the issue of CSMA by compensating excessive power consumption balancing with data transmission demands in peak traffic of the WSN environment. The implementation steps of this operation are given in Algorithm 2.

Algorithm 2. Optimization of buffer power

```
Input: n, pl
Output: buff_pow
Start
1. For i=1:n
2.     p_ttl=A(1:pl)
3.     For j=1: length(p_ttl)
4.         p_ttl1=p_ttl(j)
5.         buff_pow=f3(p_ttl1, K)
6.     End
7. End
End
```

Algorithm 2 takes the input of n (total nodes) and pl (power level), which upon processing, yields an outcome of $buff_{pow}$ (buffer power). The algorithm considers all the sensor nodes n (Line-1) and constructs a matrix of power-based *ttl*, i.e., p_{ttl} (Line-2). For this purpose, the algorithm initially constructs a matrix A with a newly generated random number. All the random numbers are assigned based on the highest power level value, i.e., pl (Line-2). It will mean that an initial buffer is formed, which retains all the power levels of sensor nodes in a random fashion in order to generate p_{ttl}.

Further, the algorithm constructs a new matrix of buffer power $buff_{pow}$ whose dimension ranges from 1 to the length of the matrix retaining information about p_{ttl}. The algorithm considers all the values of p_{ttl} (Line-3) and assigns each value to a new matrix p_{ttl1} (Line-4), followed by applying an explicit function f_3(x) considering input arguments of p_{ttl1} and K (Line-5). The intrinsic operation carried out by the function f_3(x) are as follows: i) the first input argument for this function p_{ttl1} is an integral part of the location update of the mobile sink, while the second input argument K is considered the same for an interval of mobility of sink node, ii) the function generates a matrix which retains information about generated binary information of p_{ttl1}, iii) the function then checks for a specific number of consecutive neighboring nodes as next hop of sink node; while in such case is found to be true then it proceeds towards checking the information of p_{ttl1} for all the sensors which come in between transmitting sensor and mobile sink node in next hop, iv) further, the function performs estimation of the cumulative number of routes generated from mobile sink next in next hop to following hop location. The complete operation of this function f_3(x) generates a matrix of buffer power $buff_{pow}$, which stores information about enhanced paths for facilitating energy-efficient data delivery considering mobile sink positions.

2.3. Managing dynamic location update in WSN

The proposed scheme introduces a new role of a node called an auxiliary node, which is meant for minimizing the extent of identical data transmission in WSN in forwarding the packet. One of the advantages of introducing such a role of sensor is towards minimization of burden for data transmission by normal sensors. Hence, the prime role of an auxiliary node is to transmit the message between the sensor nodes and thereby contribute towards resource-efficient routing in WSN by opting for a proper path from the transmitting node to the receiver node. As such auxiliary node performs the final delivery of the data to the mobile sink; hence they need to acquire the information of location updates about the mobile sink. The implementation steps mentioned in Algorithm 3 assist in computing the dynamic location update for an auxiliary node.

The Algorithm 3 highlights the mechanism of updating the dynamic location for an auxiliary node considering the input of n (total nodes), pl (power level), and $N_{x,y}$ (location of nodes) that, after processing, yields an outcome of dl_{up} (dynamic location update). Considering all the sensor nodes n (Line-1), the proposed algorithm applies a function f_4(x) to implement Euclidean distance between two node locations, i.e., (A_x, A_y) and (N_x, N_y) (Line-2). It should be noted that the first node position, i.e., (A_x, A_y), relates to the initial position of an auxiliary node. In contrast, the second node position, i.e., (N_x, N_y), relates to the position of the normal sensor node at that time. The proposed scheme constructs a conditional logic to check if the distance is within the range of each power level *pl* (Line-3 and Line-4). In this process, the variable Rp represents a matrix that stores the information on the power level, which is always between 0 and the maximum transmission range of an auxiliary node. The buffer power $buff_{pow}$ matrix is evaluated concerning the input argument of individual power levels *pp* (Line-5) that is further stored in matrix *rec_cy*.

Further an explicit function f_5(x) is constructed, which is responsible for discovering neighboring sensor nodes considering two variables, i.e., *rec_cy* and *Cb*. The variable *rec_cy* retains information about buffer power with respect to power levels and *Cb* retains information about common hop with respect to data structured R constructed in prior algorithm (Line-6). The outcome of this processing is stored within a random number r_{num} (Line-6) which is further used for obtaining dynamic location update dl_{up}. For this purpose, a function f_6(x) is designed considering the random number r_{num} and optimized *ttl*, i.e., *ottl* for all the sensor nodes n (Line-8). Finally, the algorithm performs the dynamic location update dl_{up} computation, which is maintained as a data structure on the *R* matrix (Line-10).

Algorithm 3. Dynamic location update for an auxiliary node
```
Input: n, pl, Nx,y
Output:dlup
Start
1. For i=1: n
2.    d=f4((Ax, Ay), (Nx, Ny))
3.    For pp=1:pl
4.         If d≤Rp(pp)
5.             rec_cy→buffpow(pp)
6.             rnum=f5(rec_cy, Cb)
7.             For nn=1:lengt(ottl)
8.                  lup(nn)=f6(rnum, ottl(nn))
9.             End
10.           R(i).dlup=[R(i). dlup, lup]
11.    End
12. End
End
```

2.4. Mechanism of communication

The proposed scheme performs an explicit set of operations in order to carry out the communication of data in the WSN environment. The core agenda of this operation is to ensure that the proposed scheme opts for a cost-effective generation process of the best route considering the spatial factor that can support the dynamicity of the nodes (especially the mobile sink node). The idea is to generate an error-free communication channel between two sensor nodes. The implementation steps for the communication process are given in Algorithm 4.

Algorithm 4. Communication process
```
Input: n, Nx,y
Output: Comm
Start
1. For i=1:n
2.     (Nx1, Ny1)←(Nx, Ny)
3.     For j=(i+1): n
4.         (Nx2, Ny2)←[Nx(j), Ny(j)]
5.         d=f4((Nx1, Ny1), (Nx2, Ny2))
6.         If d<th    478
7.             z=f7(R(i).dlup, R(j).dlup)
8.             If cb>Nc
9.                 Comm=cv(Nx1, y1, Nx2,y2)
10            End
11.        End
12.    End
13. End
End
```

The Algorithm 4 considers the input of n (total node) and $N_{x,y}$ (node position), which after processing yields and outcome of *Comm* (Communication established). Similar to prior algorithmic steps, this algorithm begins by considering all the sensor nodes n (Line-1). The algorithm initially assigns the primary node location (N_x, N_y) to the new node location (N_{x1}, N_{y1}) (Line-2), followed by incrementing the count to read the next node (Line-3) to generate a new location (N_{x2}, N_{y2}) finally. It will mean that (N_x, N_y),

(N_{x1}, N_{y1}), and (N_{x2}, N_{y2}) represent the primary (initial) location of the node, the current location of the node, and the following possible location of the node, respectively considering all the sensor node *n* (Line-4). The algorithm implements a similar function of f_4(x) in order to execute Euclidean distance towards computing spatial distance between two positions of nodes, i.e., (N_{x1}, N_{y1}) and (N_{x2}, N_{y2}) (Line-5). Suppose the newly computed distance d value is less than some cut-off value *th*. In that case, the algorithm applies a function f_7(x) which is mainly responsible for obtaining the common element between the matrix of dynamic location update dl_{up} and heuristic information from data structure *R* of dynamic location update (Line-7).

The advantage of undertaking this step is towards yielding a distinct route for data propagation without any repetitive routes, which eventually assists in faster data propagation as well as essentially addresses the loophole of CSMA, which has scalability problems in its broadcasting operation. The conventional CSMA used in WSN also suffers from long waiting times. This problem can be significantly addressed by undertaking this step, reducing power consumption. Therefore, the final information of this distinctive communication route is retained in matrix *z* (Line-7). Further, the algorithm obtains the size of this matrix z and stores it in the *cb* matrix, and it is compared with the number of nodes N_c (Line-8). This line of operation evaluates if the size of distinctive routes is comparatively lesser than the number of nodes. The justification behind this conditional check is that if there are more generations of distinctive route information, it will again lead to a computational burden as all the generated routes must be re-evaluated.

Further energy draining is also possible while processing all the distinctive generated routes. Hence, the system must ensure that the algorithm generates the least number of distinctive routes to control computational and communication overburden. Finally, a communication vector *cv* is generated, which selects the channel between two positions $N_{x1,y1,}$ and $N_{x2,y2,}$ and transmits data (Line-9). The following section discusses the outcome obtained.

3. RESULTS

The proposed framework discussed in the prior section is scripted in MATLAB, considering the usual 64-bit Windows environment, while this framework is realized via a simulation study. The simulation study uses 100 sensor nodes considering 10 selected sources for parallel transmission to generate peak traffic conditions in WSN. The simulation also considers 2 seconds to live for a beacon while packet size is between 2,000-6,000 bytes with 5 J of power level. The outcome in Figure 2 using 100 sensors exhibits that the proposed system is capable of progressive generation of communication link without any data loss. It can also be seen that the proposed system maintains linearity in the trend of communication links with respect to different nodes. The prime reason for its progressive ascent trend is due to maximum energy retention in the communication process with the availability of distinctive routes to facilitate data transmission.

The graphical outcome in Figure 3 on 100 sensors showcases that the proposed scheme can significantly reduce the network overhead by increasing the threshold. However, it can also be observed that alteration of the threshold does not significantly decrease network overhead. This infers that the proposed scheme has few dependencies towards altering the threshold for controlling network overhead. The slight increment in network overhead between threshold values of 4-5 can be justified by the increased mobility of auxiliary nodes, which gradually decreases with the threshold increase.

Figure 4 showcases that the proposed scheme encounters an increased data delivery ratio with reduced source nodes (less traffic). Considering a total of 100 sensors, when the traffic size increases from 10-40 source nodes out of 100 sensors (it will eventually mean that 10% to 40% of the sensors were considered as transmitting nodes to capture information about performance parameters), the delivery rate is found to reduce. However, this difference in reduction is quite non-significant over the increasing speed of a sink node. It will eventually mean that increasing the mobility of the sink node will not significantly impact the data delivery ratio.

The graph trend illustrated in Figure 5 shows that the proposed system considering 100 sensors consumes significantly less energy with respect to varying sink speeds. It is to be noted that the proposed scheme is an improved version of the conventional CSMA scheme targeting achieving higher energy efficiency. Therefore, the proposed scheme is compared with the conventional version of the CSMA scheme. Two variants of CSMA schemes have been considered for comparative analysis i.e., i) CSMA with congestion detection CSMA/CD, and ii) CSMA with congestion avoidance CSMA/CA over varying speeds of sink node.

In this part of the analysis, the number of 10-40 nodes is incremented randomly for the analysis in Figure 5. The outcome shows that the proposed scheme considering 100 sensors offers approximately 54% reduced energy consumption compared to the conventional CSMA/collision detection (CD) scheme. In contrast, it offers approximately 87% reduced energy consumption compared to the conventional CSMA/CA scheme. The prime reason is that the CSMA/CD scheme suffers from longer waiting time with higher energy consumption as it frequently uses request-to-send and clearance-to-send (RTS/CTS) to confirm communication. On the other hand, a conventional CSMA/CA scheme introduces additional traffic leading to more dependency on resources from sensor nodes. Hence, in peak traffic conditions with higher sink mobility, resource consumption drastically increases. However, the proposed scheme already addresses this problem by introducing optimization of routes and buffer power followed by enhancing the data communication process in a progressive way, leading to significantly lesser energy consumption.

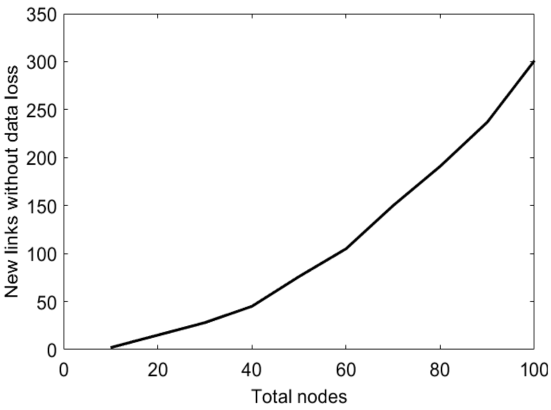

Figure 2. Generation of new links

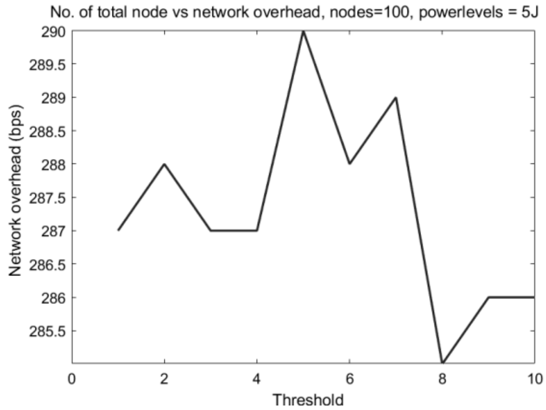

Figure 3. Analysis of network overhead

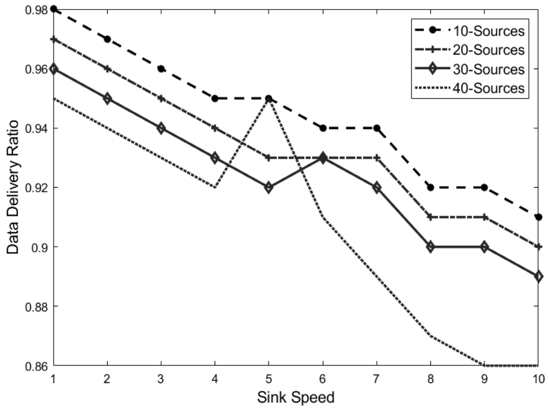

Figure 4. Analysis of impact of sources (traffic) on data delivery ratio

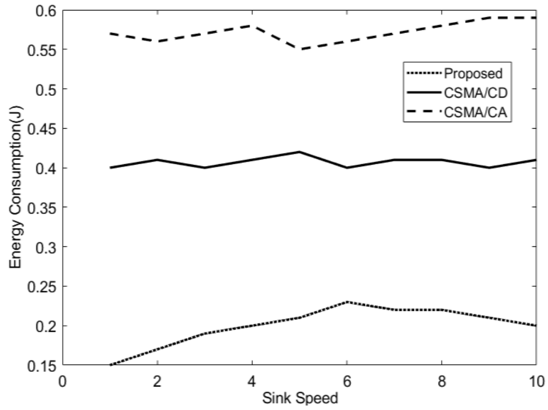

Figure 5. Analysis of energy consumption

4. CONCLUSION AND FUTURE WORK

The proposed paper presents a novel framework for facilitating higher energy efficiency. Irrespective of the simplified mechanism to implement CSMA/CD and its capability to resist unnecessary transmission, this scheme cannot be used for peak traffic conditions in WSN owing to its inherent scalability issue. A nearly similar property is also noted for CSMA/CA scheme irrespective of its proven capability towards resisting hidden terminal collision and its feature to reduce collision for more extensive data sizes. However, when exposed to peak traffic conditions by the parallel transmission of multiple sensor nodes in the presence of mobile auxiliary nodes, this scheme extensively witnesses higher dependency on control message propagation and increases the traffic burden. This characteristic adversely influenced energy consumption. Hence, the flawed character of existing CSMA is addressed in a proposed scheme with multiple contributions. The first is introducing a novel concept of route buffer, which facilitates faster availability of routing-based information using time-to-live messages focusing on the position of nodes. The second contribution is the introduction of a novel module of buffer power that efficiently allocates only necessary power for participating sensors without disturbing other ongoing communication. Then the proposed scheme introduces a novel dynamic link update mechanism that can offer seamless information to both a normal node and an auxiliary node, thereby facilitating the spontaneous establishment of a better energy-efficient route exploration process. In addition, the proposed scheme also introduces a simplified and faster deployment of communication vectors based on the energy-efficient distance between the transmitting node and the receiver node. The study outcome exhibited that the proposed scheme offers approximately 70% reduced energy consumption compared to the conventional CSMA scheme. Apart from this, it is also noted that the processing time of the proposed scheme was approximately 0.3661 s. In comparison, the conventional CSMA/CD scheme was noted with 7.5011 s and CSMA/CA scheme with 9.1379 s, proving that proposed scheme offers faster processing performance over peak traffic conditions. Future work will be further carried out towards including more case studies of heterogeneous auxiliary nodes and performance optimization will be sought in the presence of a more challenging traffic environment.

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