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AVRM: adaptive void recovery mechanism to reduce void nodes in wireless sensor networks

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Abstract

Nowadays, routing in three-dimensional environments is necessary since sensor nodes are organized in those kinds of areas. In this routing mechanism, data packets are routed using geographic routing by constructing a forwarding area. It is assumed that nodes in the network are homogeneous which contain the same energy level and sensing parameter. In this paper, we propose a new method to reduce the void node problem called Adaptive Void Recovery Mechanism, which is implemented by two folds namely position management and forwarding management concepts. Position management is implemented by sensing the surroundings using the base station and location management. Forwarding management is implemented using the assured factor value and cumulative value from the gathered data. The sensor nodes are elected with a minimized congestion packet latency value. Cluster-based routing technique is implemented to improve the network lifetime and network throughput. The proposed method is evaluated by simulation against the related methods like CREEP, EECS, FABC-MACRD in terms of End to End Delay, Residual Energy, Energy Consumption, Routing Overhead, Network Lifetime, and Network Throughput.

Keywords WSN · End-to-end delay · Data packet · GRP · Void recovery · Cluster head

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1 Introduction

Recent technology advancement in Wireless Sensor Networks (WSNs) has guided to a fast enlargement in occasion receptive applications such as health care, progression automation. Communication technology has developed rapidly using Wireless Sensor Networks in the distributed, collaborated and heterogeneous methods. Such applications need packets to be transmitted in an authentic occasion with negligible delay [1]. Geographic routing protocols (GRPs) are developed without need of path preservation and detection methodologies like traditional topological routing protocols. Consequently, it must hold active modification in the network. In real time, placements of sensors are in three-dimensional space like forest fire sensing, marine scrutinizing, mining, etc. If two-dimensional space routing protocols are deployed in 3D locations, they cannot exploit the entire prospective of the network since data must be transfer through highest route to the accomplish the destination due to mapping of the three-dimensional space to the two-dimensional space [2, 3].

The major advantage in using the GRPs is to afford the location data to nodes. The trouble in GRPs is the **void node problem** (VNP), when there are empty nodes in the forwarding region of a particular node. This is solved in 2D GRPs. But in 3D GRPs, VNP is still a problem in the network. The void recovery mechanism provides a method to resolve the VNP in 3D space using GRP by providing the real time data delivery QoS aware geographic opportunistic routing in WSNs [4]. WSNs are improving rapidly in daily life. Home computerization, vehicular networks, battle field management are few applications for sensor network real-time applications. The sensor nodes are called as the distinguished nodes that include the energy proficiency methodologies for maintaining the energy levels. The nodes also have the proficient congestion mechanism for maintaining the reliability in the transport layer. In current decade, with related situations, researchers completed their research in WSN to meet the features of Reliability [5], Quality of Service [6], and minimized power utilization [7].

In the real time scenario of WSN, routing is one of the great achievements. The growth of sensor networks contains routing of information from one node to another and further contain the process the data after reaching the destination with proper data. The routing technique [8] mainly aims to find optimal paths to reach the destination from the source node. The routing methodologies in [9–11] were used in the 2D space of the networks in which data are transfer to all possible node from the source to the base station. This diminishes the performance in the network. 3D Position-Based Adaptive Real-Time Routing Protocol for WSNs [12] was used for data aggregation and geographical routing [13]. In [14], the main diffusion category of routing was used in aggregating data by scattering events that are generated in the network. The network topology contains heterogeneous sensor nodes with distributed range of base station which provides the straight link to the cluster heads in the network.

The main problem for WSN is the energy level of sensor nodes. In [15, 16], energies of the nodes were measured but the packet delivery stimulated in the network is not assured. This stimulated the difficulty in the real-time environment, and sensed information was collected for additional process to acquire valuable data. In [17], packets were forwarded by the broadcast mechanism. The recovery mode was used to recover the last packet. This increases the number of packets in the network and also improves the packet delivery time to the sink node. A novel procedure to find a result throughout data aggregation, where the sources are differentiated, was demonstrated in [18]. The sensor nodes are categorized into individual sets of every cluster head. The node with the updated data collection is used to minimize data broadcasting in WSN [19]. A lot of similar applications in WSN where data are collected through armed applications [20]. Energy-efficient restricted greedy routing [21] focuses on 3D WSNs. This shows the network overload due to a number of beacon messages creation. The method in [22] reduces the overhead and increases the lifetime of a node in the network. The forwarding node selection by fashioning the geometric shape makes the overhead in the network.

An improved scheme was suggested to increase lifetime of the network to produce the optimized routing in WSN [23]. Dempster–Shafer related methodology [24] was utilized to minimize energy by optimizing data packet capacity in WSN. Efficient Cluster Head Election mechanism [25] was proposed to increase the lifetime of the WSN. An improved ABC algorithm [26] was proposed to sustain the stability in the WSN according to the satisfied energy consumption. The selection of clusters is elected using the parameter called the shortest path. This will minimize the active path in WSN [27]. The cluster head selection is also the parameter for the energy consumption of WSN [28].

Heterogeneous related clustering methodology identified the lifetime and the network performance using mobile node parameters. The collaborative nodes are used for the routing in WSN. The energy proficiency is also the parameter for this methodology called CREEP [29]. In EECS methodology [30], the waiting time was computed for every mobile sink in the model of mobility. The sensor node assigned the state transition model with chain model. The cluster head is chosen according to the residual energy of the sensor node, the distance between the sink node and the sensor node, and the overhead of data communication. FABC-MACRD technique [31] utilized the fuzzy model for cluster head selection. The congestion avoidance technique was also implemented to solve the network connectivity problem. All the mobile nodes are connected to the master station and the packet delivery is also improved in this technique.

The **major issue related to the methods** is each sensor node communicates data to the base station with network capability. This might require the nodes electing an enormous communication range. The sink nodes are not constantly distributed data between sensor nodes in WSN. Thus, they may process the complexity to determine the status of the present sensor node within its transmission range. The **void node problem** also affects the performance of the WSN.

From this motivation, the main objective of this paper is to design a new method which has the following attributes:

(a) The dynamic routing methodology is proposed to perform the routing of data packets using geographical methodology to minimize the energy consumption of the sensor nodes in the network.
(b) Adaptive Void Routing Management is performed to diminish the void node problem.
(c) Cluster-based Routing is implemented to increase the network lifetime and throughput.

Thus in this paper, we **propose a new method** to decrease the void node problem in which the Adaptive Void Recovery Mechanism selects the improvement of network lifetime and network throughput. Void Recovery Mechanism is implemented by using the position management and forwarding management concepts as shown above. Sensor nodes are elected with minimized congestion packet latency value. It also increases the packet delivery ratio by reducing the end-to-end delay. The cluster head is selected with the properties of adjacent position and optimal path. Node correlation value is used to ensure the packet forwarding region in a dynamic way.

The proposed method differs from the work in [29] in which the location management and position management is computed in the proposed method for effectively utilization of energy consumption. Also, it differs from the work in [30] in terms of selecting the cluster head with various dynamic parameters. From the work in [31], the proposed method avoids the network congestion and minimizes end-to-end delay.

The rest of the paper is as below. Section 2 introduces the new method - Adaptive Void Recovery Mechanism. Experiments and conclusions are covered in Sections 3 and 4.

2 Adaptive void recovery mechanism

The proposed Adaptive Void Recovery Mechanism is implemented using the forward management and the position management techniques to reduce the void node problem by performing dynamic routing with cluster head formation. The sink node plays a vital role to deploy sensor nodes within the communication range. The base station is used to coordinate the sensor nodes in the dynamic manner with the concept of probability management and node correlation methodologies. VNP Handling technique is introduced to perform the geographical based routing with performance metrics. The whole process is illustrated in Fig. 1.

In the design of the Adaptive void recovery mechanism, it is supposed that the sensor network contains η amount of arbitrarily scattered consistent nodes. These nodes have mobility and are organized in 3D. It is supposed that the communication range of the node is r and is glowing circularly. As this mechanism uses geographic routing, every node discovers its own location and the location of the target node. In some deployments, the location of the destination is pre-defined and other nodes are pre-programmed to all sensors. The objective of this mechanism is to construct the adaptive forwarding region in the form of a cone. This region uses the third coordinate of the region. By constructing this forwarding region, the forwarding nodes and the congestion in the network will be reduced. Whenever a node generates or receives data packets, it may check whether the packet has been communicated already. If the packet has already transmitted, the packet will not be communicated within the network. The initial angle (β) for the nodes is assigned as,

$$\beta = \frac{360}{\eta_s} \tag{1}$$

$$\beta \leq 360 \tag{2}$$

where η_s is the number of nodes within the network. Then, it constructs the adaptive Packet Forwarding Region (PFR) with the angle β to discover the next neighbouring node to transmit the packet. The initial angle β is known by entire nodes in the network. The node constructs the region and checks if any node found inside the region. If any node found inside the region, it selects a node based on the energy to forward the packet. Otherwise, the particular node twice the angle β and again searches for availability of nodes. A packet has the number of re-transmission value. During the forwarding of the packet, if any node is not found inside the forwarding region, there will be the change in the number of re-transmission value of the packet. The re-transmission value gets incremented by the node when there is no node available to forward the packet inside the forwarding region for a particular angle. The node then again constructs the forwarding region with the value that is double the initial value. Thus, there is greater chance of availability of the nodes. The process continues until there is availability of the node. This ends when the angle reaches the maximum angle. The packet is dropped under the following stages: 1) the packet reaches the destination node; 2) when the packet has no lifetime.

2.1 Position management

The prime objective of the position management is to recognize a packet forwarding region to forward the packet. Nodes

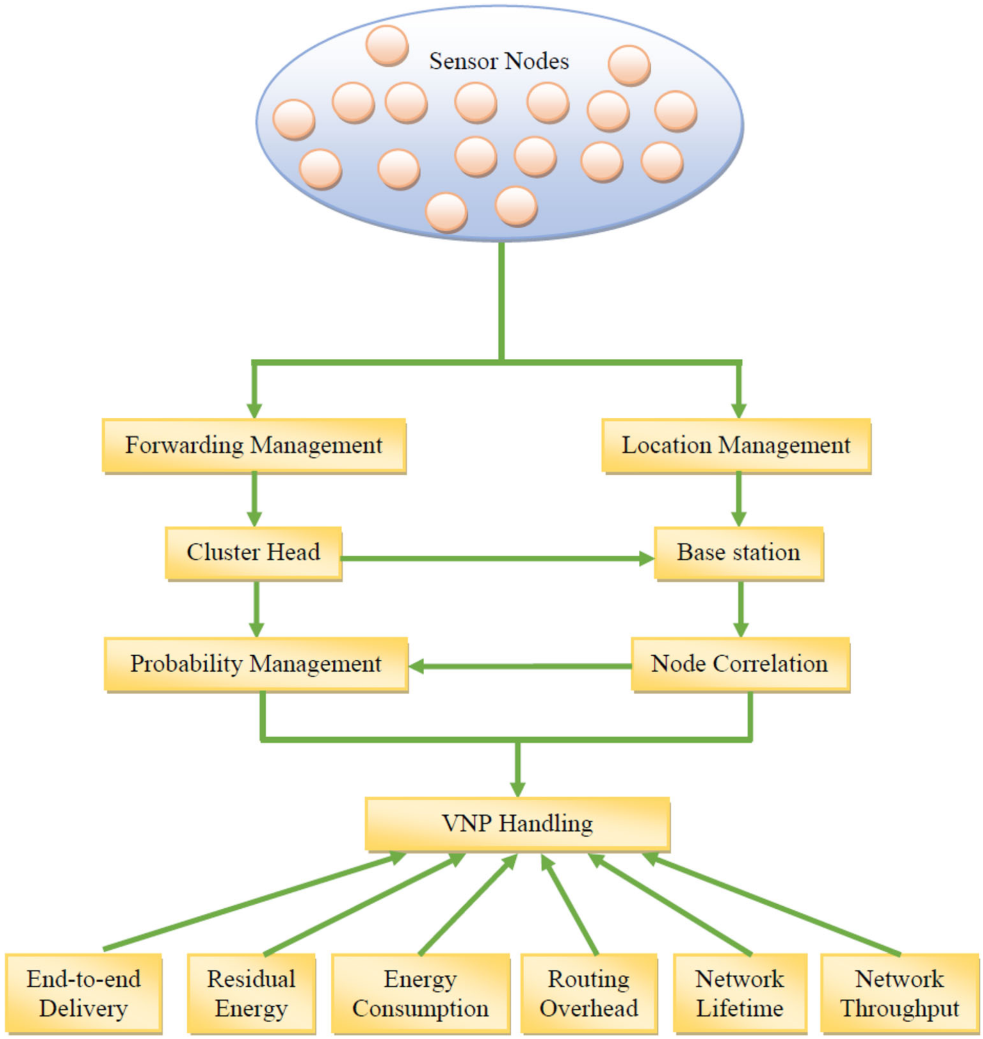


Fig. 1 Architecture for Adaptive Void Recovery Mechanism

that are positioned within the forwarding region can be considered as potential forwarding nodes. The forwarding region should be very small and it must hold at least a single forwarding node inside. The location management utility collects the packet that has never transmitted prior. The dispatcher or the forwarder node (S) appends its position of the packet so that the receiving node can check its location to identify that it is within the PFR or not. So as to recognize a node being situated inside the PFR, 2 vectors are used as the vector from the dispatcher to the target, and the vector from the dispatcher to the adjacent forwarder node. The sender's position is granted by the packet and the recipient position is pre-programmed to every node available in the network.

In the position management, whenever a node collects a packet, it constructs the adaptive forwarding region with an angle less than 360°. If it satisfies the condition, it can forward the packet; else it is stored as a void node to hold the void node problem. The initial value of the angle β can be calculated using $\beta = \frac{360}{\eta_s}$ where η_s is the entire nodes in the network. All the nodes are pre-programmed with the initial value of β during the deployment. Figure 2 demonstrates the management technique with sensor nodes and base station.

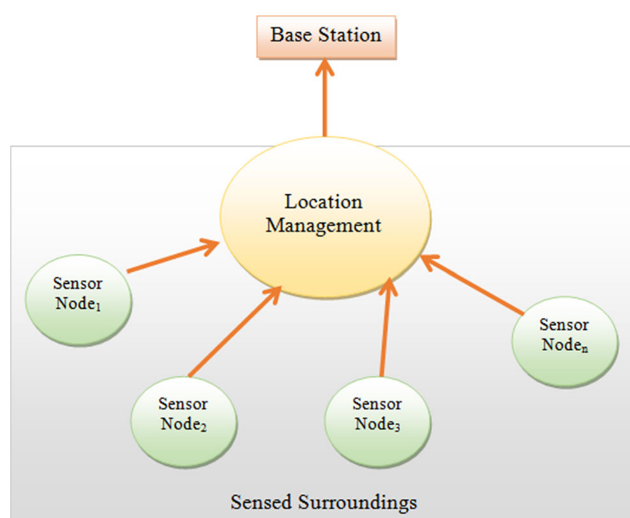


Fig. 2 Position Management Diagram

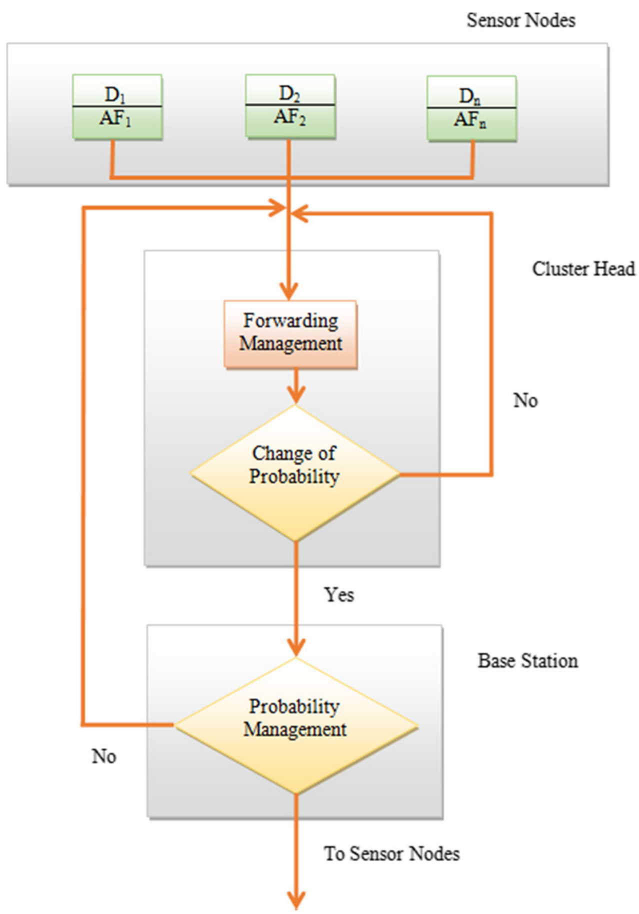


Fig. 3 Proposed Forwarding Management

2.2 Forwarding management

The prime objective of the forwarding management is to find the delay and to establish the subsequently optimal forwarding node. The forwarding management computes the assurance factor $\{AF_1, AF_2, \ldots, AF_n\}$ for each sensor data $(D_1, D_2, \ldots, D_n)$ that is acquired in real-time. An assurance function is defined as,

$$f(m, \sigma, n) = e^{-\frac{(m-n)^2}{2\sigma^2}} \tag{3}$$

For forwarding management, every node evaluates the predicted assurance factor (AF) with a threshold value. If the computed AF is smaller than a threshold, the information is ignored. Conversely, the information is delivered to the cluster head. This kind of methodology has restricted the activity of information that does not have the positive values. The last step of the Forwarding Management is based on the maximization value of the threshold.

The cluster heads are dependable for cumulative value of the sensed data from the nodes. The cluster heads begin the information at the end of every phase of information gathering. The cumulative value is computed as follows:

$$CV = \frac{(AF_1 x\, D_1) + (AF_2 x\, D_2) + (AF_3 x\, D_3) + \ldots\ldots\ldots + (AF_n x\, D_n)}{(AF_1 + AF_2 + AF_3 + \ldots\ldots\ldots\ldots + AF_n)} \tag{4}$$

where D_n is defined as the gathered data from all the nodes, AF_n is the assured factor of the gathered data, CV (Cumulative value) is the combination of the information from the related nodes. CV is a mixture of the gathered data and assured factor in the sensing surroundings. It is the matrix with a single row and multiple columns.

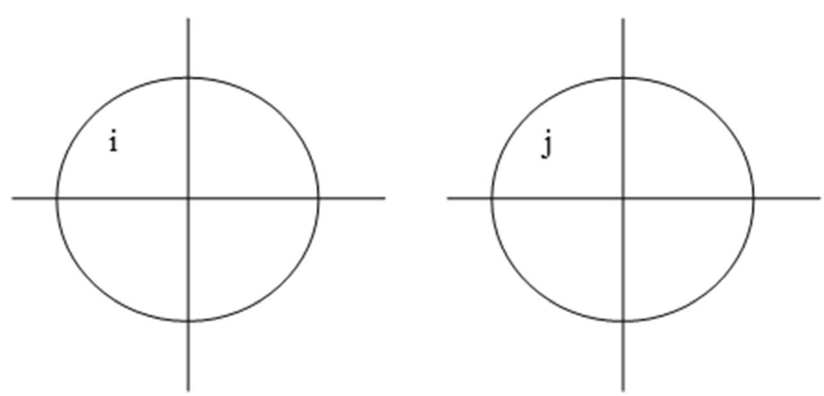
$$M_{CV} = \{CV_1, CV_2, CV_3, \ldots\ldots\ldots, CV_n\} \tag{5}$$

The calculated M_{CV} is developed by another cluster head with the result of the sensing surroundings. The base station needs organizing and processing frequently the gather probabilities that are constructed along the period. If the difference is the minimum value, the forwarding management method is used to modify the sensor nodes. Figure 3 illustrates the proposed forwarding management with sensor nodes consists of sensor data and assurance factor. The cluster head is responsible for forwarding management techniques. If the probability management is happened in forwarding management, it will send to the sensor nodes; else it will communicate to the sensor node for further operation.

2.3 Delay assessment

This guarantees that the packet gathers the details of release deadline by choosing less congestion nodes. The packet

Fig. 4 D = 0



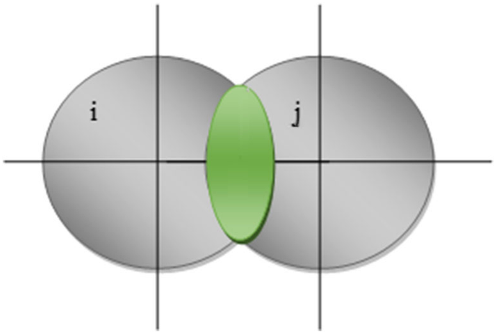


Fig. 5 $0 < D \leq \delta$

latency was represented as T_{req}:

$$\mathrm{T_{req}} = \left(\mathrm{T_p} + \mathrm{T_{pr}} + \mathrm{T_t}\right) + \left(\mathrm{h \; x \; T^{'}h}\right) \tag{6}$$

$\mathrm{T_p}$ Packet propagation time in medium;
$\mathrm{T_{pr}}$ Processing time of packet in the forwarding node;
$\mathrm{T_t}$ Time essential to broadcast the packet;
h Predictable number of hops towards destination;
$\mathrm{T^{'}h}$ Predictable required time in a hop devoid of queuing delay.

If $\mathrm{T_{req}}$ < the packet deadline, data can be self-assured. If no node is found inside the PFR, the sender realizes that the deadline of the packet has expired or there occurred void node problem.

2.4 Adaptive void recovery mechanism

Step 1: Let P be the group of n nodes arranged in a wireless sensor network.

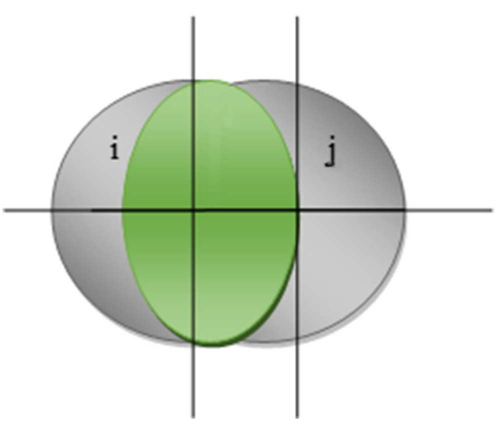


Fig. 6 $\delta < D \leq 1$

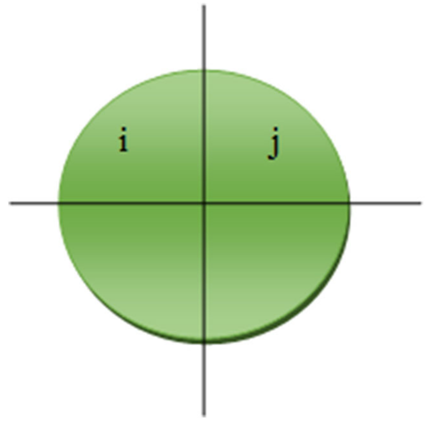


Fig. 7 D = 1

$$P = \{P_1, P_2, P_3, \ldots\ldots, P_n\} \tag{7}$$

Step 2: If *Max_value* is discovered within the communication range of the node, that particular node delivers primary position to the Base Station along with Cluster Head.

Step 3: Base station identifies adjacent position:

$$Cost(m_m, x) = \frac{1}{N} \sum_{m=1}^{N} \left(v_{\mathrm{m}} x v_m^T + \log|x|\right) \tag{8}$$

Step 4: Base station discovers the optimal path

$$v_m = z_m - H_m r_m \tag{9}$$

$$n_{m+1} = n_m + m_m v_m \tag{10}$$

Step 5: Base station delivers adjacent position (AP) to the Dynamic Cluster Head. Dynamic Cluster Head discovers 3 nodes (P_q) closer to the optimized AP.

$$P_q = \left\{P_{q1}, P_{q2}, P_{q3}\right\}, \qquad P_q \in S \tag{11}$$

Step 6: Cluster Head discovers header node $P_L \in P_q$ with superior assortment ratio (S) of Remaining Energy (R) and distance (l) from the optimal path.

$$S = \frac{R}{l} \tag{12}$$

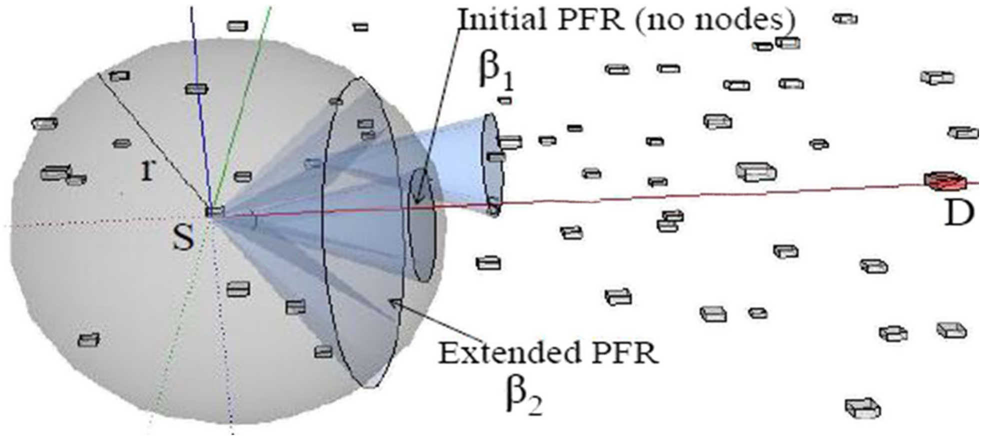


Fig. 8 PFR with and without nodes

Step 7: Identify nodes $\{\forall P_q | P_q \in \{P_{q1}, P_{q2}, P_{q3}\} \; \& \; P_q \neq P_L\}$ and compute their l from the optimal path and deliver it to the header node P_L.

Step 8: Header Node P_L computes optimal path's current position (CP) using VNP Handling technique with data delivered to the recipient. The computed CP is delivered to the Cluster Head.

Step 9: The Dynamic Cluster head computes the difference between AP and CP. It compares it with a threshold (δ).

If $|AP - CP| > \delta$

Cluster head delivers CP to the Base station.

Else

Data broadcasting is stopped to Cluster head.

Base station accumulates the AP.

End if.

Step 10: Repeat step 3 to step 9 until the optimized path is found in the WSN for every 0.50s.

Table 1 Parameters of Simulation

Parameters	Values
Size of Fields	100×100 m^2
Number of Sensor Nodes	{100, 200, 300, 400}
Static Base Station Location	(50.0, 50.0)
Dynamic Base Station Location	(100.0, 100.0)
Default energy (E_d)	0.50 J
Value of Threshold (δ)	1 m
Sensor node range	15 m
transmission range	35 m
Base station movement speed	2.0 m/s
Speed	0 m/s to 10 m/s

2.5 Node correlation

The joint amount of correlation can be calculated as

$$Cor(x) = -\sum_{i=1}^{k} prob(x_i) * \log(prob(x_i)) \tag{13}$$

$$Cor(y) = -\sum_{i=1}^{k} prob\left(y_j\right) * \log\left(prob\left(y_j\right)\right) \tag{14}$$

Cor(x), Cor(y) represent the information of node *i* and *j*. *prob* (x_i) is the probability of node *i*, $prob(y_j)$ is the probability of node *j*. Combined information can be calculated as

$$Cor(x,y) = -\sum_{i=1}^{n}\sum_{j=1}^{m} prob\left(x_i, y_j\right) * \log\left(prob\left(x_i, y_j\right)\right) \tag{15}$$

$prob(x_i, y_j)$ is the combined probability of variables x_i, y_j.

$$Cor(x,y) \leq Cor(x) + Cor(y) \tag{16}$$

If the 2 node's information are not correlated to others, then

$$Cor(x,y) = Cor(x) + Cor(y) \tag{17}$$

The degree of correlation for i^{th} node and j^{th} node can be computed as

$$Cor(x,y) \quad \setminus \quad Cor(x) + Cor(y) \tag{18}$$

D is the coefficient of correlation

$$D = 1 - \frac{Cor(x,y)}{Cor(x) + Cor(y)} \tag{19}$$

The coefficient of correlation data range is [0:1]. δ is the threshold value of correlation. If $D < 0$, it denotes the data correlated by node *i* and node *j* are independent. If $D = 0$, it denotes the data correlated by node *i* and node *j* being the

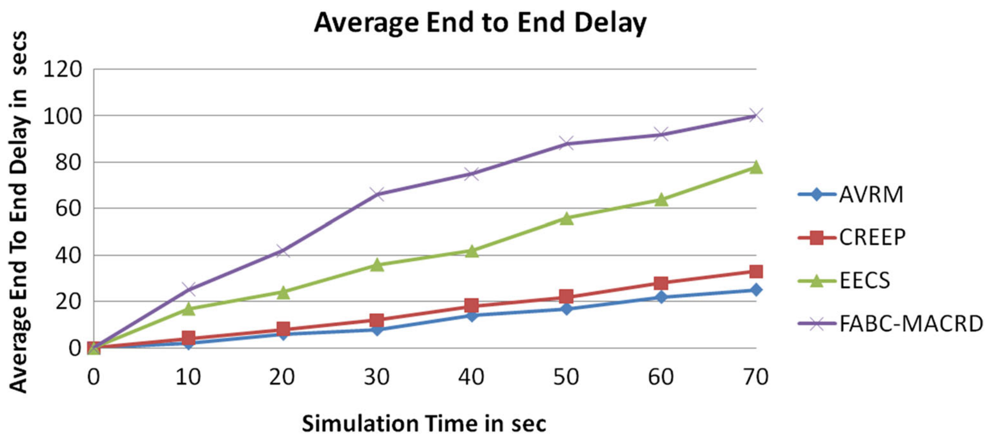


Fig. 9 End-to-end delay vs simulation time

same. When $0 < D \leq \delta$, the node similarity is minimum. When $\delta < D \leq 1$, the node similarity is maximum. The nodes following the rules of $\delta < D \leq 1$ are separated into a group. The coefficients for similar nodes can be grouped into a lot of tiny groups are called as Smaller Area (SA). For every node, which is within the smaller area is set as a Correlated Node (CN) and the length is L. The selected area can be broadcast to the head node by correlated node. Figures 4, 5, 6 and 7 demonstrate the groups.

2.6 VNP handling

The prime function of the VNP handling is to detect if the void node problem happens and solve it reliably. The VNP handling consists of two functions such as Back Pressure and PFR adjustment. Packet Forwarding Region (PFR) can be explained in three dimensional using the Fig. 8. The PFR adjustment is made when there is no node available to transmit the packet for the first time. When a node encounters the void node problem, it cannot improve at the first broadcast effort. It twice the angle value to find the forwarding nodes in the constructed region. The change in the angle happens until the value of β is less than that of the 360 and the number of retransmissions is less than the maximum value. Thus, the dispatcher node recognizes that there is no node in the region of the packet towards the target. When the sender node reaches the utmost re-transmission, it enables the back-pressure algorithm. This algorithm sets the packet flag to 1 and transmits the packet. When any of the neighbouring nodes already received the packets, it sets the packet flag to 2 and rebroadcasts the packet to its neighbour. Every node that did not transmit this packet previous sets the packet flag to 0 and transmits the packet. This effectively handles the void node problem in the network.

2.7 Wireless sensor network energy consumption model

Energy consumption is a combination of network communication and computation. The most successful method to minimize the energy consumption is to minimize it in the network. Clustering is the procedure of dividing the network into a reasonable number of clusters to accomplish energy consumption. WSN is demonstrated by an undirected graph G = (V, E), such that there is no ordinary prototype on the interchange of graph G. Cluster Head *i* transmits Allocation Table (AT) to every Cluster Managers with the highest distance (*distance*(*i*, *j*)).

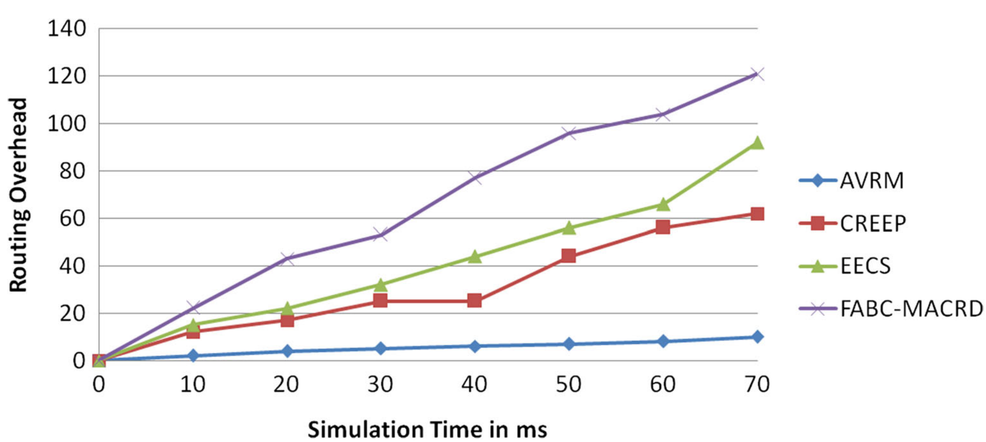


Fig. 10 Comparison graph for Routing Overhead vs. Simulation time

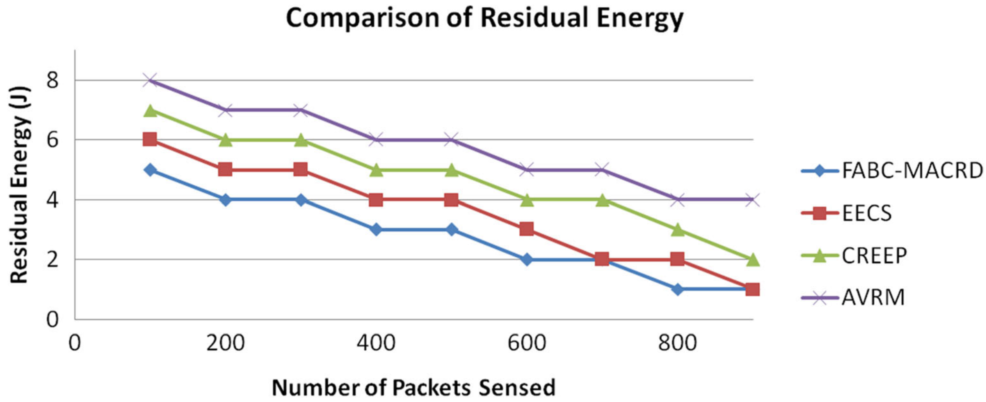


Fig. 11 Comparison graph for Residual Energy vs Number of packets sensed

$$Energy_{CH_i \to AT} = length_{CP} \text{ x } Energy_{elec} + length_{CP} \ \epsilon f_s \left[distance(i,j)_{max}\right]^2 \quad (20)$$

Cluster Managers collect AT. The energy consumption is calculated as

$$Energy_{AT \to CM} = Neighbor\ (i) length_{CP}\ Energy_{elec} \quad (21)$$

From the time slot, Cluster Mangers send information to Cluster Head *i,*

$$Energy_{CM \to data} = \sum_{j=1}^{Neighbor(i)} length_{data}\left[Energy_{elec} + \epsilon f_s\ distance^2\ (i,j)\right] \quad (22)$$

Cluster Head *i* collects all information from Cluster Managers. Energy consumption is calculated as

$$Energy_{data \to CH_i} = Neighbor\ (i)\ length_{data}\ Energy_{elec} \quad (23)$$

Cluster Head *i* summarizes all data in a cluster.

$$Energy_{A_i} = [Neighbor(i) + 1] length_{data}\ Energy_{data} \quad (24)$$

Cluster Head *i* broadcasts the data to Base Station. Energy consumption is calculated as

$$Energy_{CH_i \to data} = length_{data}\ Energy_{elec} + length_{data}\ \epsilon_{mp} distance^4 (i, BaseStation) \quad (25)$$

The energy consumption for i^{th} cluster is calculated as

$$Energy_{CLUSTERi} = Energy_{CH_i \to AT} + Energy_{AT \to CM} + Energy_{CM \to data} + Energy_{data \to CH_i} + Energy_{A_i} + Energy_{CH_i \to data}$$

$$\begin{aligned} Energy_{CLUSTERi} &= length_{CP} \text{ x } Energy_{elec} \\ &+ length_{CP}\ \epsilon f_s \left[distance(i,j)_{max}\right]^2 \\ &+ Neighbor\ (i)\ length_{CP}\ Energy_{elec} \\ &+ \sum_{j=1}^{Neighbor(i)} length_{data}\left[Energy_{elec} + \epsilon f_s\ distance^2\ (i,j)\right] \\ &+ Neighbor\ (i)\ length_{data}\ Energy_{elec} \\ &+ length_{data}\ Energy_{elec} \\ &+ [Neighbor(i) + 1]\ length_{data}\ Energy_{data} \\ &+ length_{data}\ \epsilon_{mp} distance^4 (i, BaseStation) \end{aligned} \quad (26)$$

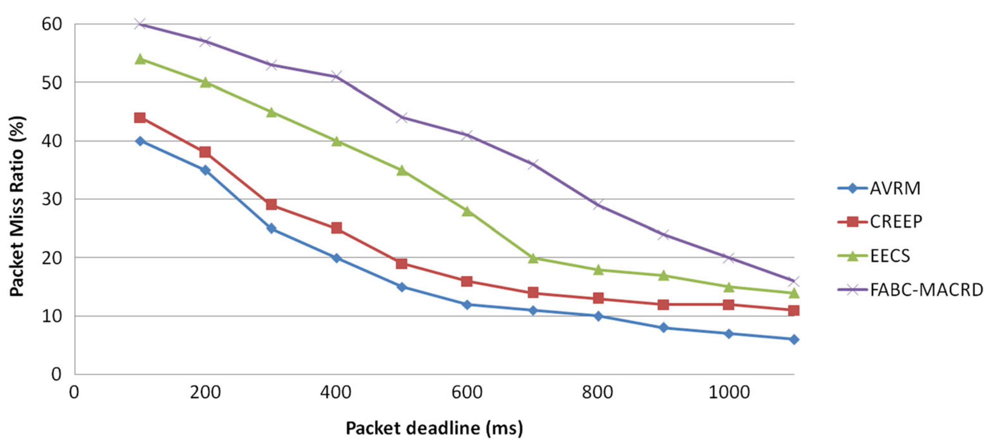


Fig. 12 Comparison graph for Packet Miss Ratio vs Packet deadline

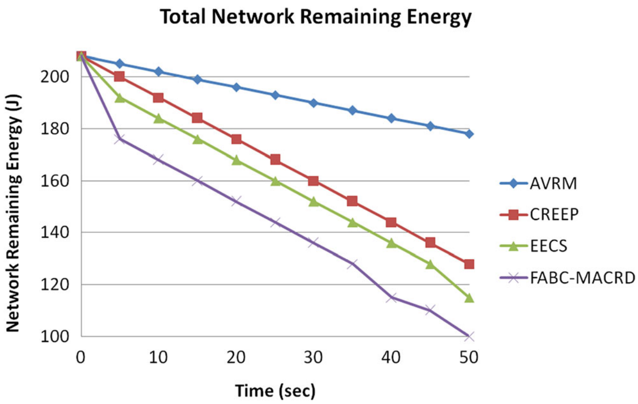


Fig. 13 Network Remaining Energy

The entire energy consumption in the network in the round n is calculated as

$$Energy_n = Energy_{CP} + \sum_{i=1}^{k} Energy_{CLUSTERi} \tag{27}$$

The maximum operation in the network round n is n_{max}. The entire energy consumption is

$$Energy_{total} = \sum_{n=1}^{n_{max}} Energy_r = \sum_{n=1}^{n_{max}} Energy_{CP} + \sum_{i=1}^{k} Energy_{CLUSTERi} \tag{28}$$

If any node proceeds as Cluster Head, energy consumption in the cluster is correlated to

$distance(i,j)_{max}, Neighbor(i),$

$distance(i,j)$ *and* $distance(i, BaseStation)$.

The above parameters do not limit the entire network's energy consumption. If we wish to stable the entire energy consumption, the total number of clusters should be known.

3 Results and discussion

Performance of the void recovery mechanism is evaluated based on Network Simulator 2 for a static Base Station model and dynamic Base Station Model. In our simulation, we show two sets of experiments as a static base station location (100.0, 100.0) and a dynamic base station location as (50.0, 50.0). The simulation network environment size is 100×100 m^2. In the assumption, each sensor node contains energy as 0.50 J and sensor node range as 15 m and transmission range as 35 m. The environment setup shows a number of sensor nodes from 100 to 400 per network. Threshold value is as $(\delta) = 1$ m. In the initial setup, nodes are deployed with static after that changed as dynamic with mobility speed varies from 0 m/s to 10 m/s and base station as moved from one place to another place based on the speed as 2.0 m/s. Due to this dynamic nature, VNP Handling shows good improvement in the network lifetime. The cluster formation is simulated in the communication range. The experiments have been implemented by creating the communication range in the Wireless Sensor Network. The nodes are dynamically deployed in the communication range. The sink node is located in the center area of the communication range. The cluster head is selected in the network using the dynamic methodology. The performance metrics for the validation of the proposed method are End to End Delay, Residual Energy, Energy Consumption, Routing Overhead, Network Lifetime, and Network Throughput.

Table 1 demonstrates the parameters of simulation. During the objective progress in the WSN of 100 nodes to 400 nodes, we have categorized the performance of the WSN in terms of power utilization. The performance of the proposed method AVRM is compared to the related methods like CREEP [29], EECS [30], FABC-MACRD [31].

Figure 9 shows the comparison graph for end-to-end delay vs. simulation. This clearly shows that the delay is nearly constant for the AVRM and varies from100 to 400 for incremental fashion. The packet generation rate is reserved stable value and is computed. The performance of the related methods reduces when the number of nodes keeps on improving the network. But the output of the void recovery mechanism seems steady

Fig. 14 Network Lifetime

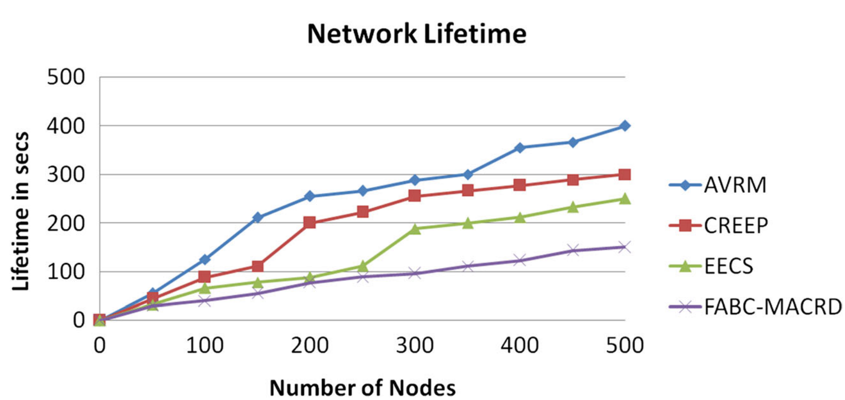
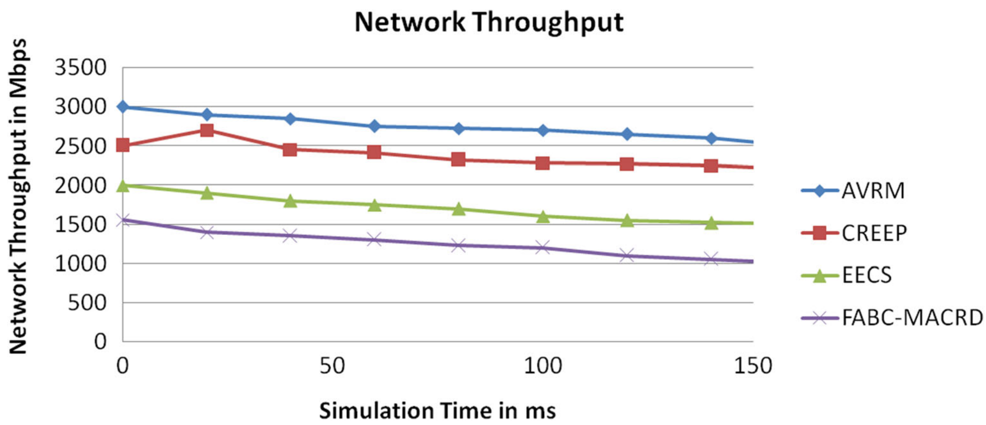


Fig. 15 Network Throughput



for the shifting number of nodes within the network. This proves that this methodology can adjust to a shifting number of nodes with a negligible quantity of delay in the network.

Figure 10 shows the evaluation chart for Routing Overhead vs. Simulation Time. The number of packets produced is increased steadily, and the delay is calculated for the produced packets. The routing overhead is related to the delay and is approximately constant for AVRM than the related methods. The performance of the network is increased whenever the amount of data was produced is keep on growing.

Figure 11 illustrates the assessment of the Residual Energy and the Number of packets sensed. Whenever the total amount of packets acquires augmented, the residual energy gets decreased.

Figure 12 shows the relationship between the packet miss ratio and packet lifetime. The packet deadline denotes the lifetime of the packet in the network. Whenever the time limit of the packet augments, the miss ratio of the packet reduces for the AVRM and the related methods. The packet generation rate and a number of nodes are kept constant. When there is increase in the lifetime of the data packet, the miss ratio decreases in the network. This shows that the miss ratio is inversely proportional to the lifetime of the packet in the network. The proposed void recovery mechanism outperforms related methods.

Figure 13 shows the total network remaining energy with respect to the time of the packet in the network. The AVRM produces good output compared to the related methods.

Figure 14 shows the total network lifetime with respect to a number of nodes of the packet in the network. The AVRM technique outperforms related techniques.

Figure 15 shows the network throughput in respect of simulation time. The proposed AVRM mechanism outperforms related methods.

4 Conclusion

In this paper, we proposed a mechanism to construct an adaptive packet forwarding region around the node to discover the subsequently forwarding node towards the sink node. The constructed region is adjusted by changing the angle to find the next node by reducing the void node problem in the network. This provides quality of service (QoS) in the network by reducing the data miss ratio in the network. The simulation results verified that the constructed mechanism has reduced the void node problem was constructed by using a forward region in the network and adjusting the angle when compared with the other protocols. This also increases the lifetime of the node in the network by selecting one forwarded node for transferring created data packets. In the future, we will examine a new routing scheme inspired by advanced machine learning for energy-efficient and a limited number of parameters as in [32–98].

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