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The Issues and Challenges of Securıty Implementatıon in Applying Reliable Communication Model PDSEER of MANET

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Abstract

When a source node in a MANET wishes to interact with another node within its transmission range, it may send data to the destination node directly. Other mobile nodes may serve as routers to allow the source node to connect with the destination node if the destination node is out of transmission range of the source node. Furthermore, due to the mobility of nodes, the route identified may fail. As a result, developing a routing protocol that discovers a route that minimizes overhead and the number of re-routing paths is critical in terms of reducing power consumption and increasing throughput. However, as the frequency of re-routing rises, so does power consumption. To conserve energy, a mobile node may select a neighbor node with the shortest distance during the route discovery phase. However, it must validate the route and network's lifespan. In order to conserve energy, it was determined to develop a routing protocol that discovers a stable route and minimizes the frequency of path breakages. In this paper, two algorithms, PDSEER and EE-BPS, are presented for attaining energy efficient transmission with transmits power control.

Keywords: *MANET, PDSEER, EE-BPS, MANET*

1. Introduction

Transmission power control algorithms may also help to decrease energy usage. Nodes decrease their transmission power to save energy while transmitting packets to their neighbors. The network capacity may also be improved by decreasing the transmission power of nodes, according to the literature. There are protocols that dynamically change the transmit strengths of nodes in order to maintain a linked topology while consuming the least amount of power. It has been shown that nodes in dense regions of the network reduce their transmission power in order to reach fewer nodes, whereas nodes in distant areas of the network increase their transmission power in order to become more completely linked. Based on the anticipated node density by which the network is expected to be linked, each node raises its transmit power until its node degree is suitably great. Performing power management on a link-by-link basis in a pure ad-hoc network, however, is a complex and time-consuming job owing to the lack of a central controller. As a result, a simpler option that is more feasible to implement is for all nodes to use the same transmit power depending on a predetermined number of neighbors. As a result, in PDSEER and EE-BPS designs, it is chosen to incorporate transmit power regulation before route finding.

2. Description of the Problem

DSR is proven to be a good reactive protocol under low mobility circumstances, but performance decreases due to the stale route issue under high mobility. The source node floods the RREQ to all of its neighbors in order to identify a route. As a result, overhead is higher. The route-finding procedure in PAMP is dependent on the node's remaining power as reported in the RREQ packet. To finish the data transmission, the remaining power of all routes is assessed in order to build additional paths. Because PAMP enables a node to handle several RREQs for a single session, it adds to the network's overhead. When a node gets an RREQ in SSBR, the RSS and broadcast time values are captured and transmitted to the source node as an RREP packet for route selection. The RSS variations are used to estimate how much data may be delivered over a given connection. The route selection in MTPCR needs the least amount of energy, but it also considers the success ratio and the number of nodes competing for the channel when calculating the power consumption.

They have not, however, focused on minimizing flooding in route finding based on received signal intensity and residual energy in any of these. These variables reduce the following issues: inadequate energy causes node failure in the chosen route, increased distance between nodes causes poor signal strength, and so on. As a result, the current designs concentrate on route discovery and selection in order to provide energy-efficient routing. Route Discovery and Selection for Energy Efficient Routing (PDSEER) is a routing algorithm in which the path selection is the sole goal, i.e. the path with the least amount of energy consumption. Nodes with low received signal strength and residual energy are not permitted to participate in route discovery. As a result, needless flooding of RREQs is avoided, and energy consumption is reduced.

3. Methodology

3.1 Energy Efficient Routing Path Discovery and Selection

The suggested PDSEER algorithm's primary goal is to minimize energy consumption during data transmission by using route discovery and selection. Because of the movable nature of the nodes, both route discovery and selection are used. The transmit power needed is modified before starting the route discovery process depending on the number of one hop neighbors chosen. To forecast connection failure between nodes in the links, RSS validation and residual energy in route finding are utilized. The route is then chosen based on a single goal function, which is energy consumption.

3.2 Model of a Network

The network is represented as a graph G=(V,E) comprising the set of Vertices (V) and Edges (E) as nodes and connections' is taken here as Total number of Nodes 'TN' for developing energy efficient route finding and selection algorithms. The set TN includes total nodes that participate in rebroadcast (TNR), i.e., reliable nodes, as well as total nodes that do not participate in rebroadcast (TNNR), indicated by TN = TNNR (TNR U TNNR). Equation may be used to calculate the likelihood of route finding (1).

$$P_{PD} = {(N - TN_R)}/{N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where, \sPPD N is the probability of discovering a route. Number of one-hop neighbors in total

TNR - The total number of nodes participating in rebroadcast

The suggested route-finding method is constructed in such a manner that the ratio of TNR to N is never zero. As a result, at least one route will be available. From Equation (1), it is clear that the existence of a connection is dependent on the number of neighbors. The PPD is 0.8, for example, if a network includes a node with five neighbors and at least one trustworthy node. This guarantees that the destination can be reached.

3.3 Energy Consumption Model

The energy consumption is computed according to Equation (2), and it is updated in the RREQ's energy consumption between source and destination (ECSD) field. The energy consumption for all (M-1) connections is denoted by ECSD. Here, ECSD is referred to as E. (x).

$$E(x) = EC_{SD} = \sum_{m=1}^{M-1} EC_{TP_m} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Equation calculates the energy usage for sending packets on the connection ij (3). The energy consumption of a single connection between two nodes I and j (ECij) is calculated as shown in Equation (4).

$$EC_{TP} = \sum_{s=1}^{p} EC_{ij_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

Where p is number of packets and p= data size/Packet size

3.4 Transmit Power Control

The transmit power level is modified to minimize the amount of power lost while sending data to nearby nodes. This power decrease, it should be emphasized, results in energy savings. This is done using the transmission range maximum (TRmax) parameter, which is defined as the maximum distance between any two nodes. The following equation is used to determine this value (4).

$$TR_{max} = \frac{R}{10 \times TN}\sqrt{\frac{\log N}{N^2}}$$ ………………………………………………… (4)

The transmit power adjustment (Pt adj) is defined as a function of N, TRmax, TR, and Pt, and is expressed as Equation (5). The value is calculated using the method provided in Equation (5), (6)

Where TR is the maximum Maximum transmission range R - Network area

The value ensures that there is at least one nearby neighbor. i.e., the value is higher than 0 even if N = 0. TRmax may be 0 or a specific transmission range value. Only if the following criteria are met will Equation (4) remain true and provide optimal outcomes.

$$TN \geq (R)^{1/3} \;;\; TR \geq \frac{\sqrt{R}}{4} \;\text{ and }\; N \geq 3 \;;$$

Where, TR - Defined transmission range

The transmit power needed for transmission, i.e., TRmax TR and Pt, is represented in Equation (5), and the value is calculated using the formula provided in Equation (6),

$$P_{t\_adj} = f(N, TR_{max}, TR, P_t)$$ ………………………………………………… (5)

$$P_{t\_adj} = \frac{N + TR_{max} \times P_t}{TR}$$ ………………………………………………… (6)

According to Equation, transmit power adjustment (Pt adj) is done primarily to minimize energy usage based on one hop neighbors (6). After that, the path-finding procedure is carried out.

3.5 RSS and Residual Energy-based Path Discovery

To find a route to all the nodes presently within the source's transmission range, the source sends out a single RREQ message. Between the source and destination pairs, the RREQ of DSR is modified by appending fields such as RSS and energy consumption. Path finding is based on RSS and the node's remaining energy after changing the power level. The closest node for transmitting data may be chosen using RSS value. The node lifespan is determined by checking the second remaining energy. The primary goal is for a mobile node to select a neighbor with the greatest RSS value during the route discovery phase in order to extend the path's lifespan. RSS in dBm for free space propagation of the connections is calculated using Equation (7), as follows:

$$RSS = \frac{P_t G_t G_r}{L}\left(\frac{\lambda}{4\pi d}\right)^n$$ …………………………………………………(7)

It can be observed from Equation (7) that the higher the RSS number, the better the link quality;

otherwise, the connection is likely to be broken shortly. When a node that is not the destination gets the RREQ, it compares the current received signal strength of the RREQ to the previously recorded RSS values of other RREQ nodes in the routing table. Figure 1 depicts a diagrammatic depiction of a forwarding node selection scenario based on RSS with an example.

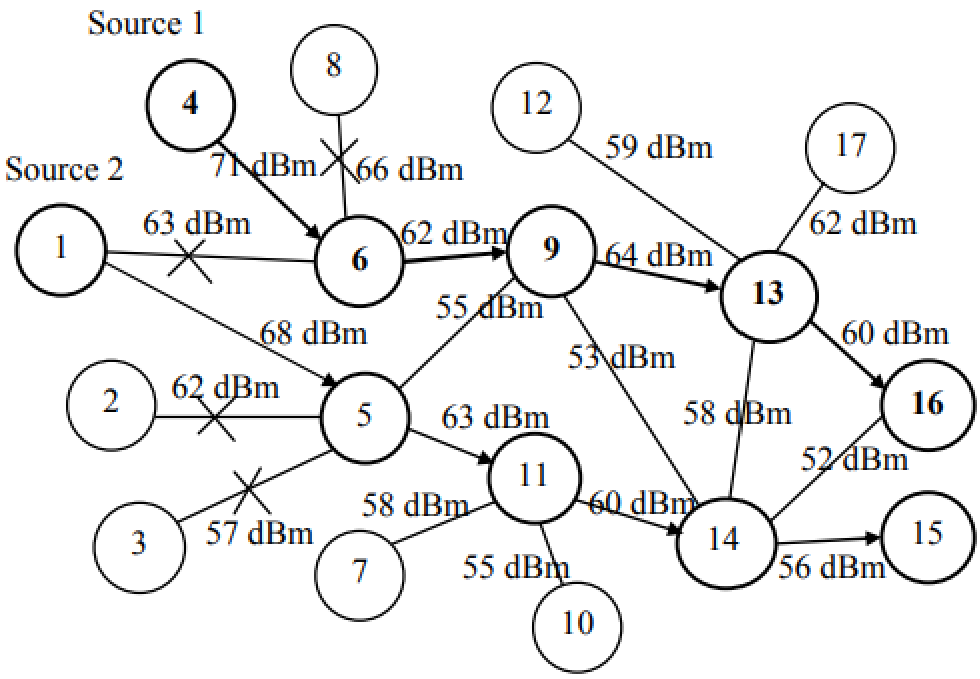

Fig.1 An example showing RSS based RREQ forwarding by a node

An example network with 17 nodes is used, including two source nodes (numbers 1 and 4) and destination nodes (numbers 15 and 16). The RREQ is sent by these two source nodes. The following is an explanation of the RSS validation of source 1. Source 1 (here node number 4) begins the route discovery process by sending RREQ to 6. Node 6 determines if it is qualified to transmit the RREQ. The received RSS value of the RREQ at Node 6 is 71 dB, which was compared to the previously saved RSS values from Nodes 8 and 1. The current RSS value is discovered to be greater, and node 6 is considered to be closer to the source than the other nodes. The residual energy is then verified using Equation (8). The judgment is made that node 6 is forwarding eligible. Once a node gets the RREQ, it follows the same procedures as the others. The residual energy is calculated as follows.

There is a possibility that the identified routes will have link nodes with inadequate energy to relay the data if the remaining energy of the nodes is not taken into consideration. The original energy value is derived from the residual energy value. Equation is used to determine the residual energy of the current node j (REj) (10). It is determined by the amount of energy available at node j prior to receipt (ENj) and the amount of energy used at node j. (ECj). The value is then checked against the specified threshold in Equation (8).

$$RE_j \geq \frac{IE}{5} \quad \text{……………………………………………………} \quad (8)$$

For all nodes, Initial Energy (IE) is considered to be constant. By sending the RREQ to the neighbor, it is determined if the node can participate in data transmission or not. The RSS of the links that the RREQ traverses is checked by each copy of the RREQ to ensure that the route creation is trustworthy. The calculation durations at node locations will vary depending on network size and traffic circumstances, and it is generally a design decision.

3.6 Framework for the PDSEER

Figure 2 depicts the PDSEER framework in the form of a flow chart. It consists of two steps: route discovery based on RSS and residual energy, and data transfer path selection based on energy consumption minimization. As shown in Equation, the route selection selects the path that uses the least amount of energy (9).

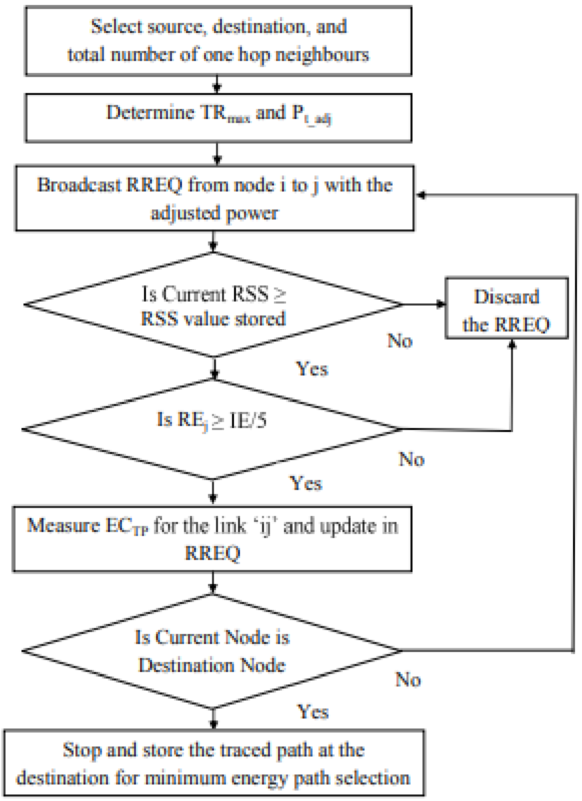

Fig.2 Flowchart showing the PDSEER framework

The flow chart in figure 2 shows that the present node takes a final choice for forwarding / rebroadcasting the RREQ after estimating its proximity. When a node gets an RREQ, it compares the current RSSrec to the RSS in the routing table. After comparing RSS of neighboring RREQ, the remaining energy of the node is checked using Equation (8), and the present node may determine whether it is suitable for forwarding. If it is the destination, it transmits a unicast RREP to the source node instead of rebroadcasting; otherwise, the procedure is repeated until it reaches the destination.

Following the discovery of dependable data transfer routes, path selection is based on the paths that use the least amount of energy in order to minimize path breakage and improve data delivery rate. Equation (2) is used to compute energy usage, which is then updated in the RREQ field. Once the destination has received all of the RREQs, it will use Equation to choose the route that uses the least amount of energy (9).

$$MECP = \min\left(EC_{SD}\right) \quad \text{………………………………………………… (9)}$$

Where MECP stands for Minimum Energy Consumption Path.

Based on this, the desired route with the least amount of energy consumption may be selected. The destination will send an RREP to the source node depending on the criteria listed above. The source node will then perform a data transfer utilizing this low-energy route. As a result of this route selection procedure, data transfer may be done more efficiently.

4. Routing with Bi-Objective Path Selection

4.1 Energy Efficient

The PDSEER design transmits data by choosing the route with the least amount of energy consumption, which is primarily to reduce the overall amount of energy used in forwarding a packet from source to destination. By forwarding data via a series of low-power transmissions rather than a single direct transfer, minimum energy routing may take advantage of exponential route loss. As a result, the network lifespan is not maximized, and nodes on low-energy routes will break early owing to their high forwarding load. As a result, it was decided to include the hop count in the goal function in the current improved design.

4.2 The Need for Hop Count in the Objective Function EE-BPS

According to the literature, all power-aware routing algorithms prefer longer routes, which raises the average relaying load for each node and therefore reduces the lifespan of most nodes. Furthermore, low-power transmissions decrease contention and improve network capacity while using less energy. This implies that a route with more low-power hops may be more energy efficient than one with fewer high-power hops. A route with more hops, on the other hand, may have a greater chance of network route failure or link-layer packet retransmission. It's worth noting that increasing the number of hops in a route has the unintended consequence of raising the probability of a connection break. Due to the extra route maintenance, this may result in an increase in control overhead. According to Haenggi & Puccinelli (2005), when packets travel a lengthy route and the end-to-end latency rises, throughput decreases. The packet loss rate increases as the hop count increases. In order to maximize both energy and hop, a bi-objective model is used.

4.3 Bi-objective Path Selection Mathematical Model

Following the discovery of reliable data transmission routes, path selection is focused on minimizing energy usage and the number of hops. The goal is to minimize route breaking and extend the life of the network. Equation (2) is used to compute energy usage, which is then updated in the RREQ field. When the RREQ arrives at its destination, it makes a choice based on the most recent energy usage and hop count for all of the collected routes (P). As seen in Equation 1, a single goal model is provided (10).

Ehrgott (2005) spoke about how to optimize multi-objective functions. The job of analyzing multi-objective optimization is found to be challenging (Kim & de Weck 2006). As a result of the aforementioned concept, a single objective function based on the bi-objective function fb(x) has been created. The first goal is based on energy usage, whereas the second goal incorporates the hop count. The goal function is defined by giving both the energy and the hop equal weight. This is due to the fact that minimizing energy without taking the hops may result in a route selection with a higher number of hops. Minimization of hops without a minimal energy route may shorten the network's lifespan or choose a more energy-intensive way. However, the aim of the design is to keep both to a minimum. The weighted sum method to bi-objective optimization yields Pareto optimum solutions, whose value is dependent on the weight factor value. The bi-objective function-based mathematical model for single-objective route selection $f_b(x)$is defined as follows,

$$f_b(x) = \min\left(\alpha \frac{E(x)}{\beta} + (1-\alpha)H(x)\right) \qquad 0 < x \leq P \qquad \text{……………………………… (10)}$$

Where,

- α - Weight parameter varying from 0 to 1
- β - Normalizing coefficient
- x - Number of paths 'P'
- E(x) - Energy consumption of the path
- H(x) - Total number of hops in the path

The desired route may be determined using Equation (10), which uses the least amount of energy and has a lower number of hops. After verifying based on fb, the destination will send an RREP to the source node for data transfer (x). The hop count is expected to be higher than or equal to three. If is 0, route selection is solely determined by the hop hop count. If is I, then energy consumption is a factor. As a result, the value selection should be made in such a way that it minimizes energy and hop count while making a choice in path selection. In order to maintain a balance between energy and hop count, the normalizing coefficient is added. This is just a function of the greatest energy used during a single hop along the chosen route.

If the energy is in j, the value of must be in j as well. The product of the highest energy value in one hop and H is value (x). For example, if the energy E(x) is 2 J and the hop H(x) is 3, E(x) / H(x) = 2 J / 3 = 0.666 J, and the highest energy value in one hop is taken as the closest whole number of 1 J.

If the decimal value is between 0.1 and 0.4, the highest decimal value is assumed to be 0.5. On the basis of the goal function, the best choice may be made based on energy, hop, or a combination of both.

After verifying using Equation (10), the final route selection is made as shown in Equation (11). The following Equation shows that fb(1) is the preferred data transmission route.

$$f_b(1) < f_b(2) < f_b(3) < \ldots\ldots\ldots\ldots\ldots\ldots\ldots f_b(P) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

As a consequence, based on Equation, the route selection for improving performance is the lowest value of both goals (10)

- For numbers that is higher than zero but less than one.
- Exceptions to the rules of selection
- Exceptions

The criteria for selection are as follows:

Equation (10) becomes zero, and fb(x) becomes simply a function of hop count. The participating nodes in the chosen route may use a lot of energy. This constraint is disregarded since the goal is to create a route with balanced energy consumption and hop. If the value of is one, then the second component in equation is also one. If the value of is one, the second term in equation will be one.

Equation (10)'s second term will be removed, leaving fb(x) to be simply a function of Energy. In order to have a route with the least amount of energy consumption and hop, this condition becomes invalid.

4.4 Bi-objective Mathematical Model Numerical Illustration

Table 1 shows a numerical representation of the route selection model based on the specified objective function provided in Equation (10) for various combinations of energy and hop. It should be noticed that for various choices of, the value of fb(x) is lowest for the route with 7 J as E(x) and 3 as H. (x). As a result, this route is chosen as the optimal way for maximizing both energy and hop.

Table 1 Numerical example -values off$_b$ (x) for different combination sof energy and hop

E(x) (J)	H(x)	β (J)	$f_b(x)$ value for different values of α ranging from 0.1 to 0.9								
			0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4	5	5	4.58	4.16	3.74	3.32	2.9	2.48	2.06	1.64	1.22
5	4	6	3.68	3.37	3.05	2.73	2.41	2.10	1.78	1.47	1.15
6	3	6	2.8	2.6	2.4	2.2	2	1.8	1.6	1.4	1.2
7	3	7.5	2.79	2.59	2.38	2.17	1.97	1.76	1.55	1.34	1.14

If is one, route selection becomes entirely energy dependent, and if is zero, path selection becomes hop dependent. Figure 3 depicts the tabulated data as a graph. Four sets of energy consumption and hop are collected, and the data is displayed using a parameter range of zero to one.

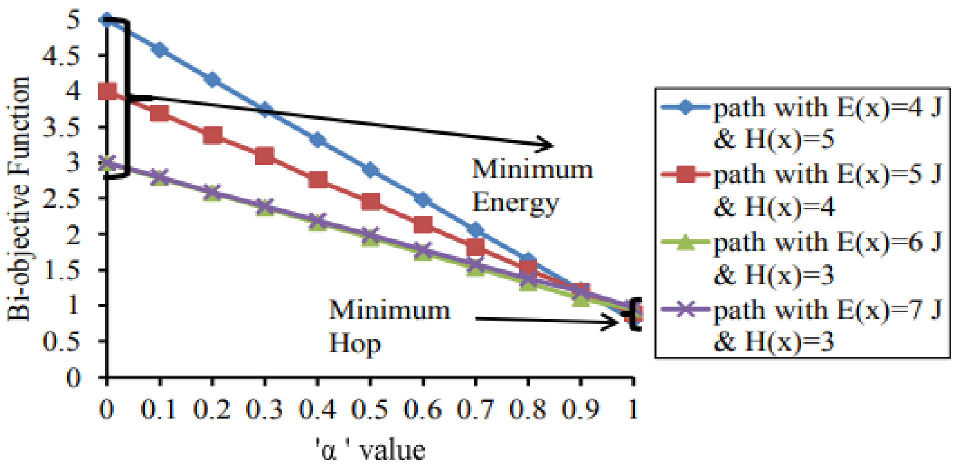

Fig.3 Path selection $f_b(x)$ for different combinations of energy and hop

Assume that the value of += o corresponds to a zero energy function, and that fb(x) selection is solely based on minimal hop and vice versa. It is obvious that the ultimate data transmission route is the one with an Energy value of 7 J and 3 hops, in which fb(x) offers us the lowest t values for all values of he, and he is chosen as 0.5 for the simulation study.

5. Results

The route discovery method and path selection algorithm are part of the simulation analysis. The simulation lasts 900 seconds, and the data are collected after 10 runs to get the steady state value.

5.1 Performance Analysis of PDSEER

The performance of the PDSEER design is compared to DSR (Johnson & Maltz 1996), PAMP (Yang et al 2008), SSBR (Chen et al 2010), and MTPCR (Chen et al 2010). (Chen & Weng 2012). Control packets, energy consumption in the route discovery process, packet delivery ratio, energy consumption, and the number of path breakages in the path selection process are the parameters for the study.

Figure 4 shows the study of the amount of control packets required for identifying a route based on RSS for various numbers of nodes.

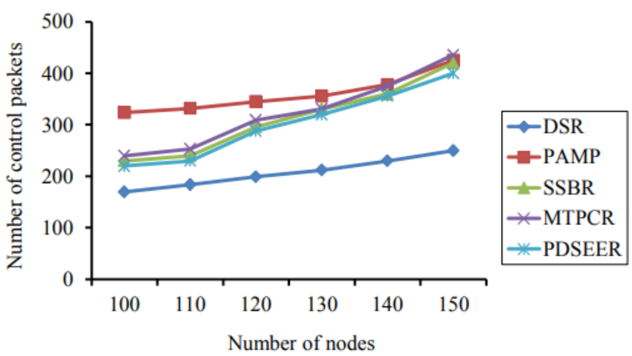

Fig.4 Number of nodes vs. control packets

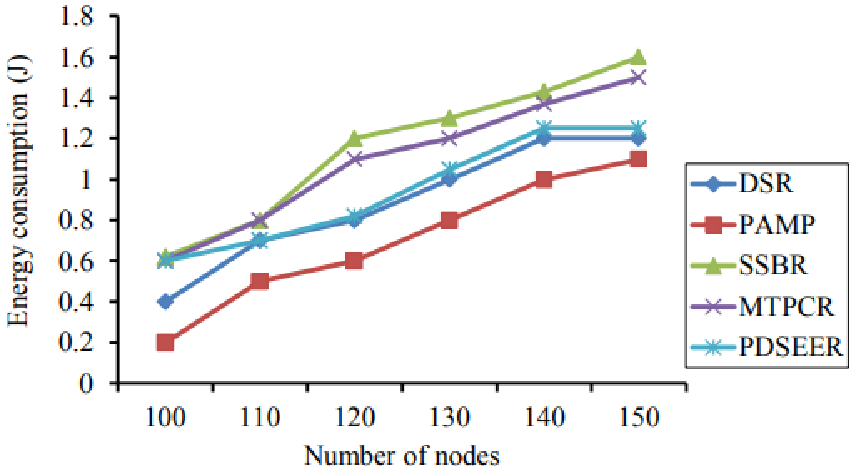

Fig.5 Energy consumption analysis in the path discovery process

Because of the limited number of RREQ broadcasts based on RSS and residual energy, the number of control packets for the PDSEER is lower than for PAMP, SSBR, and MTPCR, as shown in the overhead analysis graph in Figure 5. Because of the dependable path finding, the PDSEER has a higher amount of control packets than the DSR. As a result, the number of RREQs sent to set up the route increases.

6. Conclusion and Future Scope

With decentralized security management, no permanent infrastructure, and no lasting hierarchy, mobile networks are highly flexible and adaptable. They're more susceptible to attacks like passive surveillance and aggressive interruption as a result of this. As a result, network security is a must for Mobile Ad hoc Networks.

It was discovered that current routing algorithms did not take into account the remaining battery power of nodes. In most cases, the shortest path routes are used to connect two nodes. Such algorithms may result in a rapid depletion of the battery at nodes that are common to the network's most frequently utilized routes. To address the aforementioned problems, three novel protocols for efficient route discovery in MANETs are suggested in this study, and their performance metrics are compared to the current methods FACES, EPAR, and RCRP.

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