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Intelligent Approach for Design and Analysis of Power Efficient Routing Algorithm in High Speed MANET

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Abstract:

In a mobile ad hoc network, individual nodes can move about and connect with one another to create networks on the fly, bypassing the requirement for fixed infrastructure. Because of constraints on both bandwidth and battery life, creating energy-efficient protocols is currently a top priority for MANETs. The MANET nodes rely on a battery supply, which has a finite amount of energy that it can store. The network lifetime is reduced when a node's power fails since the node can't forward packets on behalf of other nodes. Traditional MANET routing protocols, such as DSR and AODV, do not take nodes' energy state into account when transferring data and instead employ a common transmission range. In this research, the author introduces (PARA), a novel power-aware routing algorithm that makes use of transmission range and node speed variability. The suggested approach employs the AODV protocol's route discovery method. Using Network Simulator-2, we model both protocols and compare their results over a range of network conditions, looking at variables like energy usage, network longevity, and number of living nodes. The findings of this study demonstrate that the suggested algorithm yields effective outcomes.

Keywords: *AODV, Power aware, Routing, PARA.*

1. Introduction

A MANET, or mobile ad hoc network, is one that is not governed by a single entity. The network's nodes communicate with one another and transfer data packets via a wireless interface [1-4] . These movable nodes in the network can run user apps and forward packets on other nodes' behalf; they can also act as hosts. This paves the way for seamless inter-networking of devices and people in places where no such infrastructure exists. Establishing resilient dynamic communications for rescue and emergency operations, disaster relief, military networks, indoor applications in business, and home intelligence devices are notable instances of MANET [5,6].

The dynamic topology, bandwidth-constrained wireless links, and resource-constrained nodes of MANETs make the development of routing protocols a difficult undertaking. Figure 1 shows the basic architecture of mobile ad hoc network in wireless mode [7-9]. Proactive and reactive protocols alike have been developed in an effort to meet a wide range of requirements, such as the following: minimal power consumption, rapid convergence of routes, optimization of metrics (such as throughput and end-to-end delay), and absence of loops [10].

The goal of this research is to prolong the life of the network by tackling the issue of power-efficient routing. Because most modern mobile hosts run on batteries, making good use of that energy is crucial [11-14]. When certain nodes are actively engaged, their energy resources drain quicker than those of other nodes [15.16]. This might cause the network to divide, which shortens its lifespan. So, one major concern with ad hoc wireless networks is how to lower their power usage. An extended node life can be achieved through careful control of the three main power sources: the battery, the transmission, and the system. In order to maximize the lifetime of the network, this research proposes a technique that minimizes the energy consumption at the nodes [17-20]. Modifying the power levels at nodes is accomplished by the transmission power control technique [21]. Route Discovery makes use of

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standard power levels. With each new pair of nodes, the distance between them is used to determine a new power level.

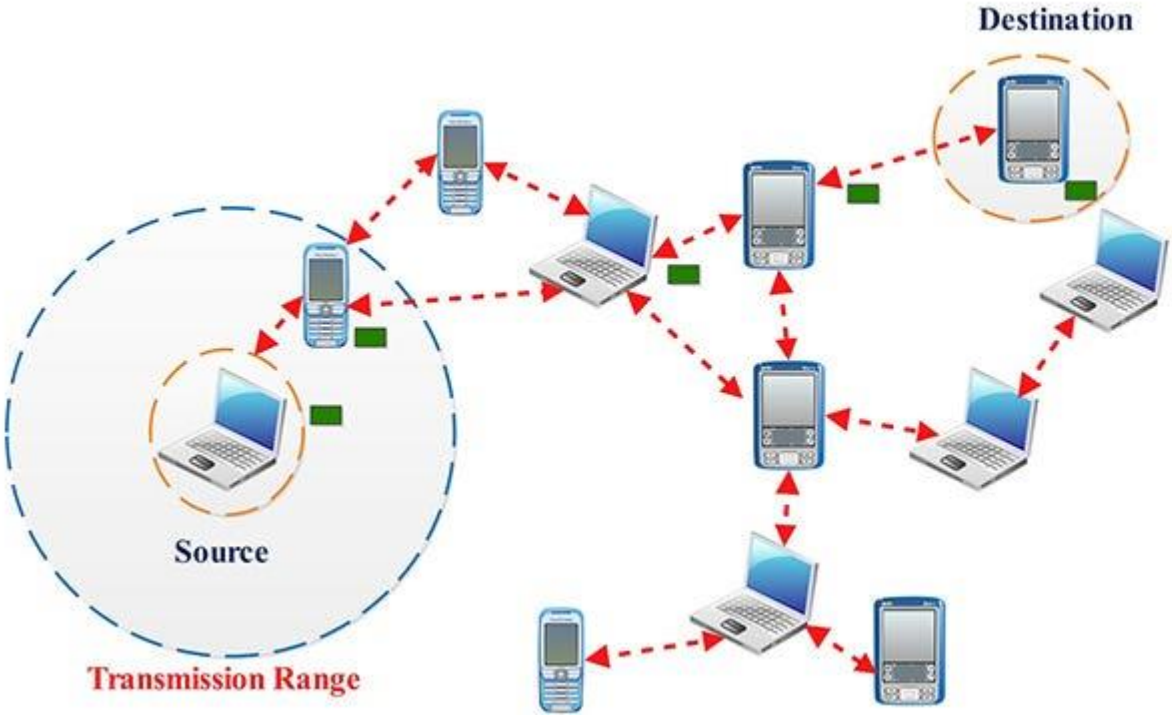

Figure 1: Basic Structure of Mobile ad hoc network

Here is how the remainder of the paper is structured. The relevant research in power-aware routing strategies is discussed in Section 2. The suggested PARA algorithm's inner workings are covered in section 3. In Section 4, you can find the NS-2 simulator's setup for the simulation environment. Section 5 provides an explanation of the simulation results. Section 6 concludes the whole thing.

2. Literature Survey

The development of Power-efficient routing algorithms has been the focus of much research. Whether a node is actively communicating or not, its energy consumption is minimized. A few ways to reduce the energy consumption of individual nodes when they are actively communicating are transmission power control and load distribution. Another way is to put them into sleep or power-down mode when they are not in use [22-25]. Opting for a lower transmission power level minimizes interference for potential transmitters but increases the number of forwarding nodes needed to deliver packets to their destination. On the other hand, a higher transmission power level reduces the number of nodes needed for packets to reach their destination, but it causes excessive interference in a shared medium [26-29]. To achieve this goal of energy balance among all mobile nodes, the load distribution technique chooses a route with underutilized nodes instead of the shortest path.

To efficiently and swiftly find the path, MANET routing relies on variables such as topology, router selection, request initiator location, etc. There are two main types of conventional routing protocols: proactive and reactive. These algorithms aren't cognizant of the fact that each node in the network uses energy [30]. When a route is required, reactive routing protocols either find it or keep it. As a result, proactive protocols produce less overhead. Source routing and hop-by-hop routing are two types of reactive routing protocols. Some examples of source routing include Dynamic Source Routing (DSR), while AODV is a hop-by-hop routing system.

A simple, efficient, and on-demand routing technique for mobile nodes in multi-hop wireless ad hoc networks is DSR (Dynamic Source Routing). In DSR, the routing information is kept (and updated) at the mobile nodes themselves, rather than depending on the routing table at each intermediate device. This is called source routing. 'Route Discovery' and 'Route Maintenance' are the two primary components of the protocol; they operate in tandem, as needed. The protocol enables several paths to a destination, eliminates routing loops, supports one-way links, relies solely on "soft state" for routing, and quickly discovers new routes in the network [31-33].

For mobile wireless ad hoc networks, there is a self-starting, loop-free, multi-hop on-demand routing called AODV. AODV uses a route table rather than a route cache to find paths and does not rely on source routing [34]. Through the use of the Route Error (RERR), Route Request (RREQ), and Route Reply (RREP) messages, it enables mobile nodes to promptly react to link breaks and changes in the topology of the network. Using sequence numbers, it keeps active routes only while they are in use and deletes stale routes, which are routes that are not in use.

When given a source-destination pair and a static network, Flow Augmentation Routing (FAR) determines the best route that minimizes the total cost of all links along the route. To avoid overloaded nodes, Online Max-Min Routing (OMM) maximizes the least residual power, which extends the lifetime of the network and individual nodes in wireless ad hoc networks. highly intelligent Assuming that a source node knows the position of its neighbors and the destination, Localized Routing (PLR) is a distributed, energy-aware routing method that is localized. Instead of focusing on finding energy-efficient paths, the primary objective of Minimum Energy Routing (MER) is to optimize the existing paths by changing the transmission power to the exact amount needed to reach the next hop node. An analysis of the effects of variable range power regulation on connection at the physical and network layers [35-36]. The authors find that, compared to common range transmission, variable range extends the longevity of the network. we find the ideal range of transmission for nodes while route request messages are pouring in.

3. Methodology

Making the network power conscious is the major goal of the method that has been developed. The protocol's energy-efficient design is created by adjusting the nodes' transmission range. By distributing control over the power level of each packet at each node, variable transmission range allows one to influence the network's energy consumption. An increase in transmission range decreases the number of nodes required to reach the destination but increases interference, while a decrease in transmission range requires more forwarding nodes but saves energy consumption. The Route Discovery phase involves all of the nodes interacting with their nearby neighbors. To ensure that the most efficient use of energy is made during packet transmission, once the route has been determined, each node adjusts its transmission range according to the distance between the source and destination nodes. What follows is an explanation of the suggested algorithm:

ALGORITHM:

Input:
- Initial common transmission range (transmission_range)
- Waiting time for RREP messages (T_wait)

Output:
- Established path between source and destination
- Routing table with node positions (n_hopX, n_hopY)

Procedure_PARA_Algorithm():
while true:

- Step 1: Route Request (RREQ) Broadcast
  generate_RREQ()
- Step 2: Waiting for Route Reply (RREP) Messages
  RREP_messages = wait_for_RREP(T_wait)
- Step 3: Process Route Reply (RREP) Messages
  process_RREP_messages(RREP_messages)
- Step 4: Distance Calculation
  distance = calculate_distance(user_location, intermediate_nodes)
- Step 5: Nearest Node Selection and Routing Table Update

```
        nearest_node = select_nearest_node(distance)
        update_routing_table(nearest_node)
```

- Step 6: Transmission Energy Computation

```
        energy = compute_transmission_energy(current_node, nearest_node)
```

- Step 7: Path Maintenance

```
        maintain_path()
```

- Step 8: Path Accessibility Check

```
        if not is_path_accessible():
            # Start over if the path is no longer accessible
            continue
```

- Procedure generate_RREQ():
  # Code to generate and broadcast Route Request (RREQ) packet
  pass
- Procedure wait_for_RREP(T_wait):
  # Code to wait for RREP messages for T_wait time
  pass
- Procedure process_RREP_messages(RREP_messages):
  # Code to handle and process Route Reply (RREP) messages
  pass
- Procedure calculate_distance(user_location, intermediate_nodes):
  distance = hop count(RREP Node sequence number - Transmitting Node sequence number)
- Procedure select_nearest_node(distance):
  # Code to determine the nearest node based on distance
  pass
- Procedure update_routing_table(nearest_node):
  # Code to update routing table with nearest node's position
  pass
- Procedure compute_transmission_energy(current_node, nearest_node):
  $$\mathbf{Pr=PtGrGt(\lambda/4\pi R)^2}$$
- Procedure maintain_path():
  # Code to keep the established path between source and destination
  pass
- Procedure is_path_accessible():
  # Code to check if the path is still accessible
  Pass

4. Setup Of Simulation Environment

Network Simulators-2 (ver. 2.34) and the wireless extensions given by CMU are used to conduct the simulations. The 802.11 MAC protocol is utilized, the channel is Wireless Channel/Wireless Physical, the probing model is Free Space Propagation Model, the queuing model is Drop Tail/Priority Queue, the mobility model is Random Waypoint.

Every simulation makes use of a unique number of nodes inside a 1000 x 1000 m^2 simulation space. All of the nodes roam the entire region to mimic the dynamic environment. Different speeds, ranging from 2 m/sec to 40 m/sec, were taken into account.

The chosen source of traffic is Constant Bit Rate (CBR), and each packet is 512 bytes in size. In order to determine the routes, a variety of source-destination pairs (ranging from 5 to 25 links) were utilized. Each simulation was executed for a duration of two hundred seconds. Each node started with an initial energy of 100 Joules, 5 W for transmission and 1 W for reception. Table 1 shows the all the parameters used in this research.

Table 1: Parameters used in Simulation

Parametr	Initilization
Simulation Time	150 sec -250 sec
Simulation area	1000*1000
Node Speed	5-40 m/s

Number of Nodes	50
Rest Power Consumption	0.03 W
Transmitted Power	5 W
Idle state power	0.0005 W
Received Power	1 W
Sleep mode	0.0002 W
Starting Power of Node	100 J
Packet Interval	4/sec
Packet Size	512 bytes
Traffic State	CBR
Connection count	Total nodes/2

5. Result & Discussion

With PARA in place, AODV serves as a case study. Both the AODV and PARA protocols have been simulated to see how they perform. The following parameters have been used to compare performance:

(i) **Network Lifetime:** This parameter can be defined in various criteria's as: First node of the network dies OR Time taken for total nodes of the network dies OR Time taken to n nodes of the network dies

(ii) **Total Power Consumption:** This is calculated according to the number of communications in the network and calculated as:
P_{Tx} = (1.65 * Packet Size)/2x10^6 (1)
P_{Rx} = (1.1 * Packet Size)/ 2x10^6 (2)

(iii) **Total Number of Alive Nodes:** this is calculated according to the threshold power which is set to be 50% of the initial power of the node.

When evaluating different routing protocols, Network Lifetime is an important performance indicator to consider. To begin, the number of exhausted nodes is used to measure the lifetime of the network. Therefore, the network lifetime is improved when there are fewer nodes that drain the energy. It is later determined that the lifetime of a network is equal to the time it takes for half of the nodes to die away.

Changes to the node's transmit power are required to alter the transmission range. As a simulation method, free space propagation is what the suggested algorithm uses. The transmit power of nodes can be determined using the Friis transmission equation, which is:

$$Pr = PtGrGt\left(\frac{\lambda}{4\pi R}\right)2 \quad (3)$$

The sentence states that the received and transmit powers are Pr and Pt, respectively, while the transmitter and reception antenna gains are Gt and Gr, the distance between the nodes is R, and the wavelength is λ.

Gt and Gr are assumed to be one in the simulations, with λ set to 0.125 m (at an operating frequency of 2.4 GHz). With a 2 Mbps transmission bandwidth, the IEEE 802.11 [16] MAC protocol provides a received power range of -81.0 dBm to -110 dBm, hence -84 dBm is chosen as the constant received power. Therefore, Pt may be determined using equation 3 and the distances between the nodes.

In Figure 2, we can see that AODV and PARA have different network lifetimes when nodes move at speeds of 10 and 40 m/sec, respectively. We will assume that there are 10 connections.

The energy consumption of the network nodes begins to rise at a rate of 91 seconds for AODV and 96 seconds for PARA, respectively, when the nodes' speeds reach 10 meters per second. The distributed network lifetime of PARA remains superior to that of AODV even when the speed is raised to 40 m/sec. The reason for this is that the number of nodes experiencing energy exhaustion is reduced as the transmitted power is adjusted based on the shortest distance in PARA.

The network lifetime is shown in Figure 3 with different pause times. At lower pause time values, PARA outperforms AODV. Network mobility decreases and PARA returns to its typical AODV behavior as pause time increases.

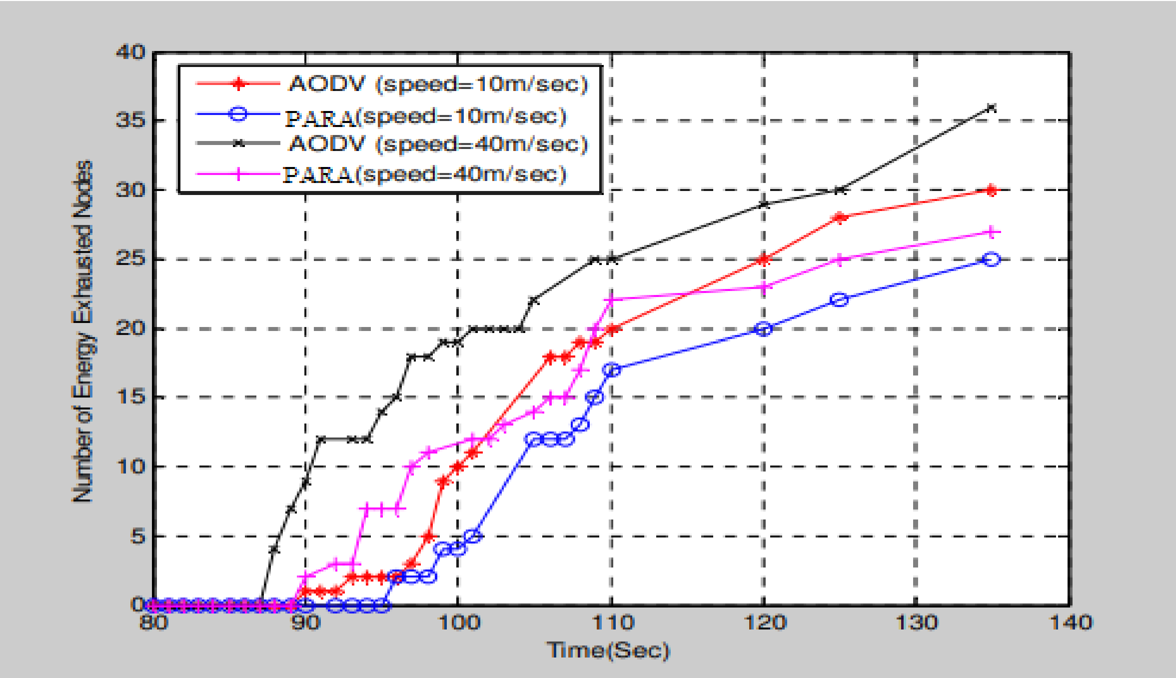

Figure 2: Number of Energy Exhausted Nodes along with Time and different Node speeds

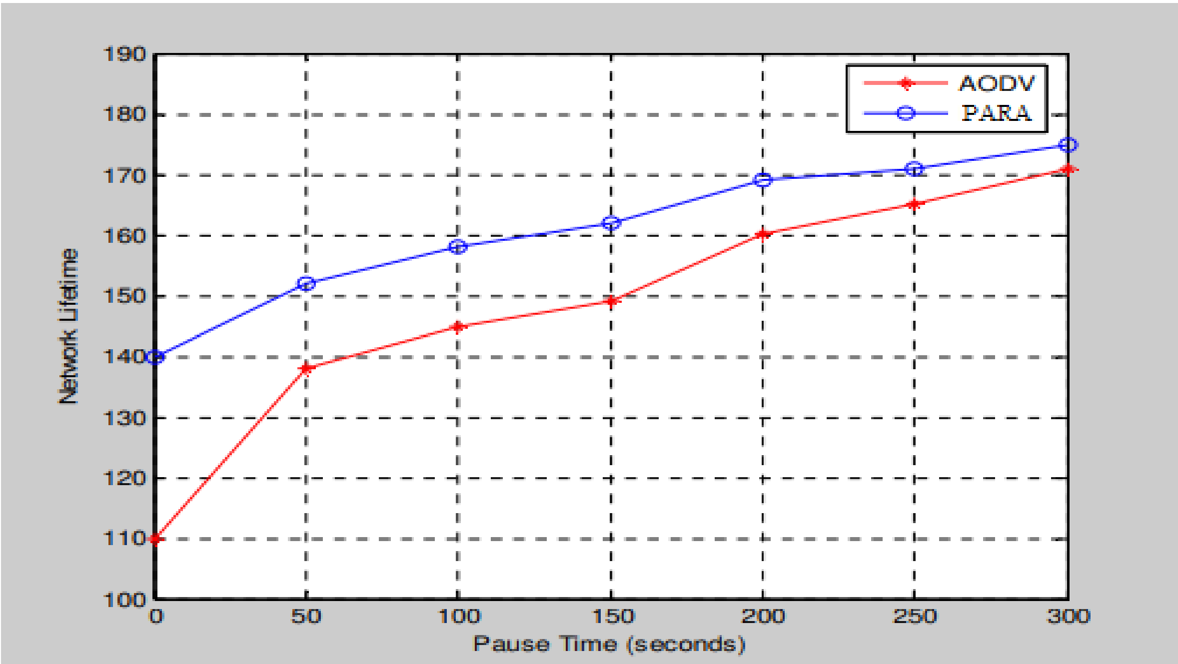

Figure 3: Network Lifetime vs Pause Time of the Transmission

Total network energy consumption as a function of node count is illustrated in Figure 4. All of the nodes in the network are traveling at a pace of 10 meters per second and there is no pause time between them. The number of connections is half of the total number of nodes. At the beginning, when there are fewer nodes, the energy consumption of PARA and AODV is similar. When the network density increases, PARA uses less energy than AODV. This is due to the fact that PARA maintains a reduced total energy consumption rate because to its variable transmit power.

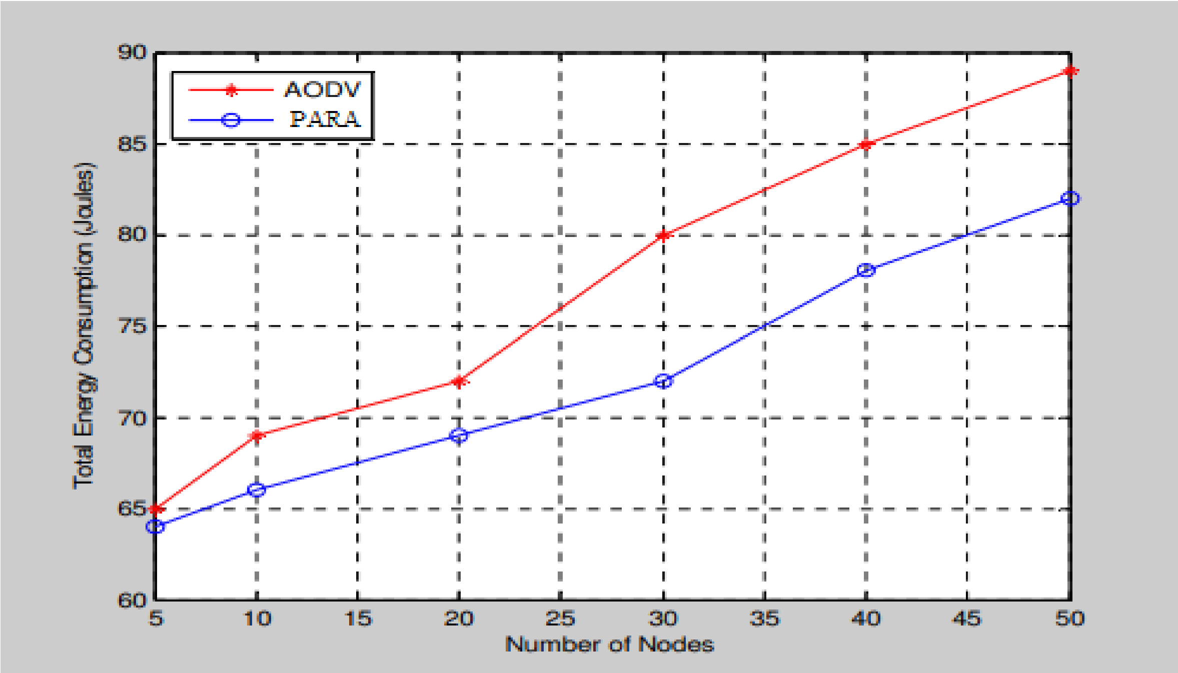

Figure 4: Total Energy Consumption according to the Number of Nodes increased

Figure 5 shows the overall energy consumption as a function of the number of connections in a 50-node network. As the network load increases, it is evident that PARA operates better than AODV. When compared to the AODV protocol, PARA reduces network energy usage by 10% to 20%.

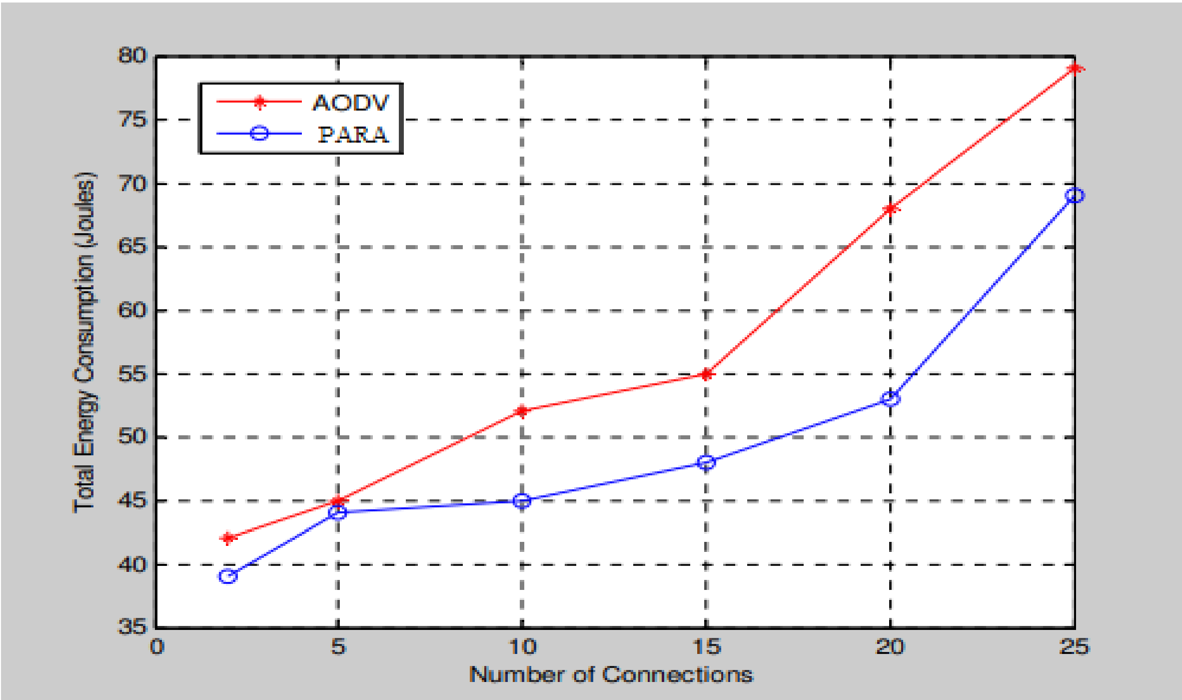

Figure 5: Total; Energy Consumption along with total number of Connections

Figure 6 shows that the energy consumption varies as the nodes' speeds increased as high speed network. Due to the increased mobility of the nodes at faster speeds, routing overhead increases due to the increased frequency of path breakage and the subsequent need to seek new routes. When compared to low speeds, these lead to an increase in energy usage. It bears repeating that PARA outperforms the AODV protocol by 10% to 20%.

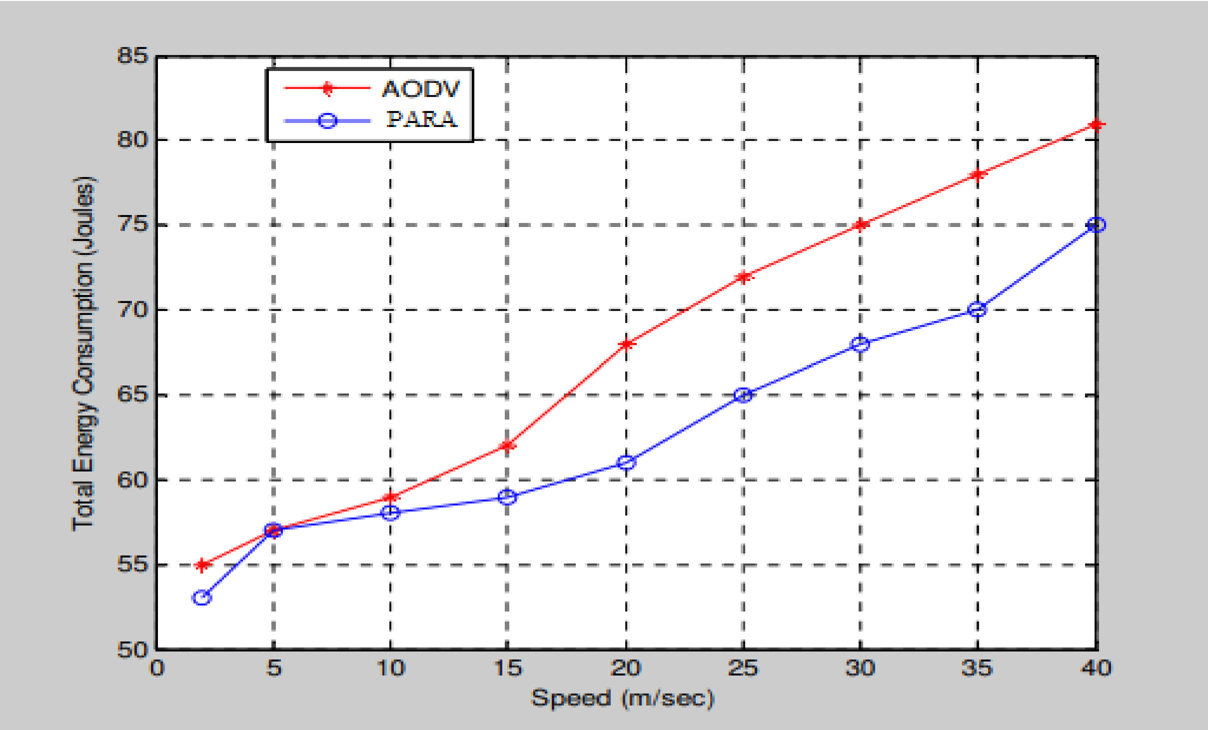

Figure 6: Total Energy Consumption along with varying Node Speed

Figure 7 shows the results of 50 nodes running at 10 m/sec. A graph is drawn showing the change in AN as the number of connections is varied. An interval of zero seconds is taken into account. The stronger the procedure, the higher this metric should be. As the number of nodes transmitting data increases, the network load causes the number of alive nodes to decrease in relation to the number of connections. The fluctuation in PARA is better than that in AODV. When contrasted with the AODV protocol, the number of live nodes in PARA is higher.

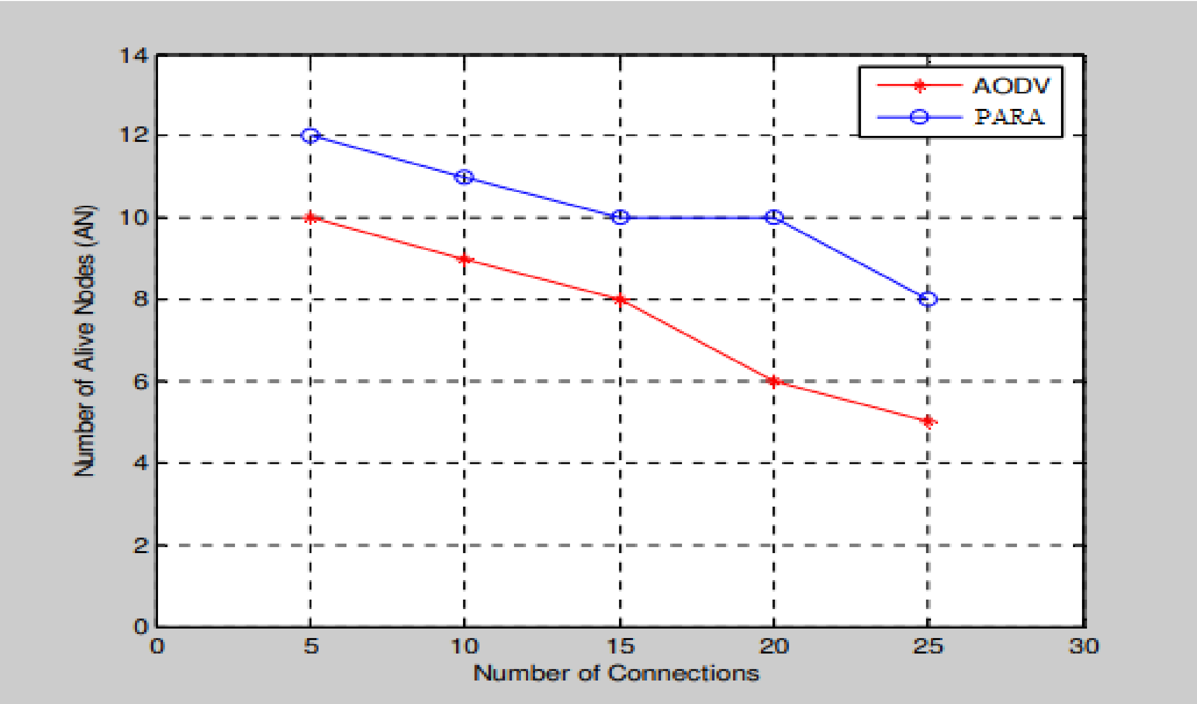

Figure 7: Number of alive Nodes along with the Total number of Connections in the Network

6. Conclusion

One of the key issues in MANETs has been to build a protocol that is energy efficient. An effective energy-aware MANET routing scheme that accounts for different node speed and variable-range transmission is the goal of the proposed work. In comparison to conventional speed and range AODV, PARA enhances network lifetime and displays greater performance in terms of energy consumption, according to the simulation results. On average, we see a 10% decrease in overall energy consumption and a 10% increase in network lifetime. As compared to AODV, PARA results in a 10% increase in the number of live nodes remaining at the end of the simulation.

Over the lifetime of the network, the energy status of each node plays a significant role. To reduce the amount of energy needed to transmit data, AODV considers the distance between the nodes while picking a route, selecting nodes with the shortest distance. The proposed approach uses a variable range of node speed and transmission range to improve energy consumption at each node. This is because the power of the transmitter is adjusted at each node before data transmission, allowing the network to make effective use of its nodes. In the future, the author will simulate the suggested technique for sparse media and real-world situations, as well as for additional metrics such as link layer overhead, pause duration, path optimality, and so on.

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