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Fibonacci Sequence Based Power and Delay-Aware Protocol for Mobile Ad Hoc Networks

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Abstract: *Wireless Ad Hoc networks generally operate with limited battery power. Thus, reducing the energy consumption becomes a crucial topic in the design of Ad Hoc routing protocols. In order to improve the quality of the real-time applications, it is essential to generate routing approach that support Quality of Service (QoS) parameters such as delay, energy spent packet delivery ratio and network throughput. This paper explores a novel Fibonacci sequence based power and delay-aware routing protocol to increase the throughput and packet delivery ratio. The simulation results show that the FPDAP protocol has achieved an enhancement on packet delivery ratio, up to 91%, as compared to the Ad Hoc On-demand Distance Vector routing protocol (AODV) protocol and Ad Hoc On-demand Multipath Distance Vector routing protocol (AOMDV). On the other hand, the FPDAP protocol has scored a lower delay time and energy consumption compared with AODV protocol and AOMDV protocol.*
Keywords: *AODV; AOMDV; FPDAP; QoS; NS2*

I. Introduction

A wireless ad hoc network is a circulated form of wireless network. This network is known as ad hoc because it is not dependent on a pre-existing structure, such as routers in wired networks or access points in managed wireless ad hoc networks (wireless network). Rather, each and every node of the network has a contribution in routing methods by forwarding data for rest of the nodes, so the determination of which nodes forward the information is made non static on the basis of the connectivity of the network. In adding up to the classic routing, ad hoc networks can use flooding for forwarding data. Dynamic routing - Unlike static routing, in this type of routing, the routers are responsible for building and exchanging the routing table information according to the changes that occur in the network topology. Henceforth, the router must have the information of network status so that it can take the correct decision. Flexibility of dynamic routing is more in comparison to the static routing because it has an ability to find out the congested paths [1]. There are three different type of category, dynamic routing category can be one of these categories [1,2].

Reactive protocols -Reactive protocols are on demand routing protocols where the network does not have a prior knowledge of the routes between its nodes until a source node request a route to transmit data to a specific destination node. The high latency and route setup are the main disadvantage of the reactive algorithm [2]. Ad Hoc On-demand Distance Vector Routing Protocol (AODV) is an example of on-demand routing protocol. Proactive protocols -Networks that deploy proactive routing protocol need full information about the routes between each pair of nodes regardless of whether the nodes need to transmit data or not. Nodes can easily obtain routing information and nodes can easily initiate a session. Consuming bandwidth and massive amount of data needs to be saved in the memory of each node in the network is the limitation of reactive protocol.

Hybrid protocols -Hybrid protocols mix both reactive and proactive protocols to exploit the advantages of each one of them [1,2,3]. Zone Routing Protocol (ZRP) is one of the most popular Hybrid Routing Protocols, where the network nodes are grouped into zones [2,4]. The hierarchy of reactive, proactive, and hybrid protocols with examples on each: Now how can decide which of these protocols should deploy in design? The answer depends on the provisioned goals of an ad hoc routing protocol [5]. These goals are summarized in the following points:1. Reduce the Control Overhead: Control packets consume the network power, bandwidth and since these two factors are limited in MANETs researcher have to find a design that reduces or mitigates such overhead [5,6].2. Reduce the Processing Overhead: We have to find a simple routing algorithm with least complexity. 3. Multi-hop Routing Capability: The routing protocol must have the ability to keep the communication between source and destination nodes by discovering alternative multi-hop routes.4. Dynamic Topology Maintenance:5. Quality of Service Support: The degree of service quality should also be taken into consideration in designing the routing protocol. Here, there is a need of multi-path in the routing protocol to increase the quality of service in the network, reduce the delay and collision in the network.

Rest of the paper organizes as follows: Section II, gives a brief description of AODV and AOMDV protocol and limitations of existing approaches .Section III, describes the FPDAP protocol with flowchart and example. Section IV, contains simulation environment, performance metrics and results by comparing AODV and AOMDV. Section IV, Conclusion and future work. Section V, References.

II. Related Work

In this section, there are reviews of many protocols proposed for solving the congestion problem. In [7], Sambasivam et al. identify multiple paths during the route discovery process. Each path is maintained using the unicast periodic update packets. The unicast periodic update packets goal is to compute the signal strength for each hop that composes the alternatives paths. At any point of time, their algorithm selects the path that has the highest signal strength in order to transmit data packets. However, this approach may compromise the battery's life. Javan and Dehghan [8] show that some of multipath routing algorithms in MANETs distribute the data packets along the different routes simultaneously using the node disjoint routes. This algorithm increases the data delivery ratio and minimizes the average of E2E delay in MANETs. Yahya Tashtoush, Omar Darwish, Mohammad Hayajneh [9] explains Fibonacci Multipath Load Balancing protocol (FMLB) which distributes transmitted packets over multiple paths through the mobile nodes using Fibonacci sequence to increase packet delivery ratio and throughput. This approach is not energy aware approach. To overcome this problem, a novel approach is proposed which is multipath in which Qos parameters throughput,E2E delay, packet delivery ratio, energy consumption are suitable for real time applications. There are two basic protocols which are necessary to propose our work:

1. Single path routing
2. Multipath routing

1. Single path routing is type of routing in which source have single path to reach the destination. It is not suitable for large network because of selection of uni-path, so it causes congestion. AODV protocol is single path routing protocol which have two phases route discovery and route maintenance.

When a source node needs to communicate with destination node in a network and if source do not have a route to destination, source node initiates route discovery process and starts broadcasting a route request packet along with a sequence number in order to overcome flooding of the route request. Each node checks the routing table to see if it has route to destination when a node receives a route request. Route response id sends back to source node if it exits a route to source, else the hop count is incremented by one and the route request is rebroad casted[10,11,12,13].Figure 1 illustrates the process of AODV routing protocol.

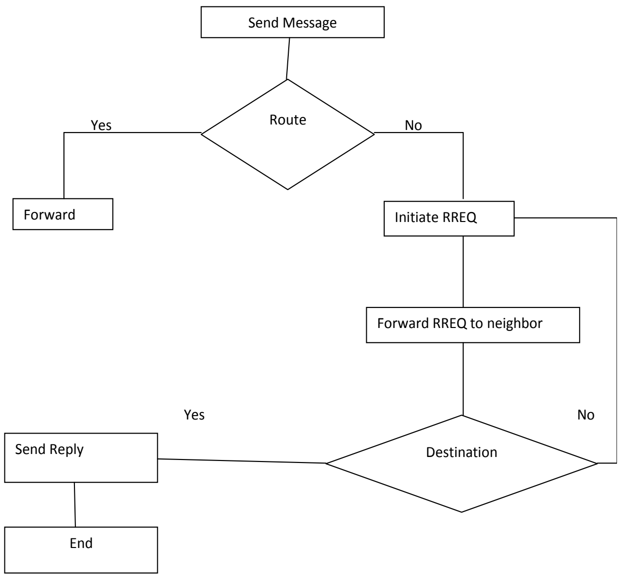

Fig.1 Request process of AODV routing protocol

2. Multipath routing: To overcome the weakness of single path routing, multipath routing is used in which source selects multipath to transmit the data to the destination. Multipath routing decreases congestion in the network.Route discovery process started by AODV through a route request (RREQ) to the destination throughout the network. Whenever a non-duplicate RREQ is received, the intermediate node records the previous hop and checks for a valid and fresh route entry to the destination. The node sends a route reply (RREP) along with a unique sequence number to the source. On the time of updating the route information, it

propagates the route reply and gets further RREPs if a RREP has either a larger destination sequence number (fresher) or a shorter route found., AOMDV has been developed from a uni path on-demand routing protocol AODV to eliminate the occurrence of frequent link failures and route breaks in highly dynamic ad hoc networks.The AOMDV protocol finds node-disjoint or link-disjoint routes between source and destination. Link failures may occur because of node mobility, node failures, congestion in traffic, packet collisions, and so on.

III. The Proposed Work

In this section, we introduce the Fibonacci sequence based power and delay-aware protocol (FPDAP).This protocol is based on multipath routing to distribute the packets from source to destination with consideration of lifetime (battery power).It meets the requirements of real time applications such are throughput, delay and packet delivery ratio (pdr).

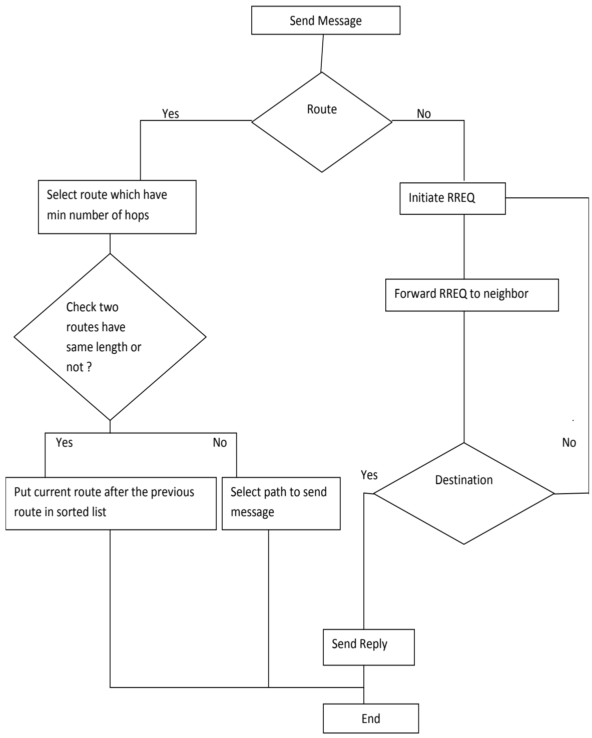

Fig.2 Request process of FPDAP routing protocol

The aforementioned figure explains the different operations of FPDAP. Message is sent from source to check the route availability, incase route is unavailable then it works as request process of AODV protocol else send message to that route which have lowest number of hops after that it checks that routes which have same length. In case of routes with same length latest route will be considered after the older route in the list; this will help in balancing load and avoiding congestion by allocating data packets over multiple routes. This can be explained with the example network in Fig. 3, where node S wants to communicate with node D. There are four possible routes between S and D which are {S, E, F, D}, {S, G, H, D}, {S, A, B, C, D}, and {S, I, J, K, L, D}. If we choose to limit the number of routes to be three, then the routes {S, E, F, D}, {S, G, H, D} with three hops and {S, A, B, C, D} with four hops could be chosen, while the route {S, I, J, K, L, D} with five hops should be ignored. Routes can be sorted with the number of hops in an increasing order. Weight will be assigned to each route on the basis of number of hops associated to that particular route. Hence, route {S, E, F, D} will have a weight of Fibonacci (3), route {S, G, H, D} will have a weight of Fibonacci (2) and route{S, A, B, C, D} will have a weight of Fibonacci (1).

Assuming the source node has five packets to send: Out of the total 2 Packets are sent through the {S, E, F, D} route since Fibonacci (3) = 2 as explained in Eq. (1). _ out of remaining 3 packets 1 Packet is sent through the {S, G, H, D} route since Fibonacci (2) = 1. _ 1 Packet is sent through the {S, A, B, C, D} route since Fibonacci (1) = 1. The last 1 packet of the 5 packets is sent through the {S, E, F, D} route again. Taking number of routes as constraint to 7 maximum.

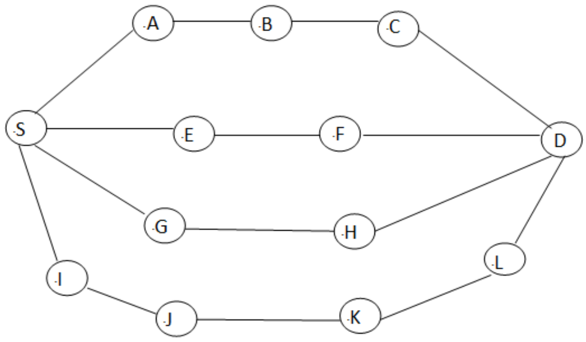

Fig.3 Structure of FPDAP routing protocol

Let us choose a single shortest path such as AODV on the same network example it uses the path {S, E, F, D} and ignore the remaining paths, this approach will make network congested and will result in more dropped packets. Consider k path on the basis of number of hops arranged in ascending order, then the following weights will be assigned for these paths by FMLB algorithm Fibonacci(k), Fibonacci (k _ 1), Fibonacci (k _ 2), ... Fibonacci (2), Fibonacci (1), respectively. The Fibonacci series can utilize the shortest paths in more well-organized way than other feasible choices; also it can achieve the load balancing by distributing packets through different routes with different number of hops in a behavior that assurance less congestion. It also guarantees the participation of long routes in load balancing mechanism.

IV. Result And Simulation

(1) Simulation Enviornment

NS2 simulation package is used to calculate the performance of the proposed Fibonacci series power based delay aware protocol approach when compared with earlier protocols such as Ad Hoc On-demand Distance Vector routing protocol (AODV) protocol and Ad Hoc On-demand Multipath Distance Vector routing protocol (AOMDV).The parameters and values of the simulation environment for various scenarios are mentioned is this given in the table.

Table 1 – Parameters and Values

Parameters	Values
Number of nodes	50
Routing Protocol	AODV, AOMDV and FPDAP
Transmission Protocol	TCP
Traffic Type	CBR
Network Size	1000*1000m
Packet Size	512bytes
Pause Time	2,4,6,8 and10ms
Simulation Time	600sec

(2) Performance Matric

In this paper, we chose the throughput, end-to-end delay, pdr and energy spent as the performance metrics for the three routing protocols AODV, AOMDV, FPDAP:

- Throughput: It represents the average number of bits received fruitfully by the destination node per second.
- End-to-end delay: It represents the average of the difference between the time of the packet delivery to the final destination and the generation time of this packet.
- Packet Delivery Ratio (Pdr): The ratio of packets that are successfully delivered to a destination compared to the number of packets that have been sent out by the sender.
- Energy consumption: It is the consumption of energy or power.

(3) Results

This section describes about the comparative performance of the proposed Fibonacci sequence based power and delay-aware protocol (FPDAP), AODV protocol and AOMDV protocols. The performance evaluation of the proposed Fibonacci sequence based power and delay-aware protocol is performed based on the performance metrics such as average delay, energy spent, packet delivery ratio and average throughput. The comparison of Average delay between FPDAP, AODV and AOMDV are given in the figure below.

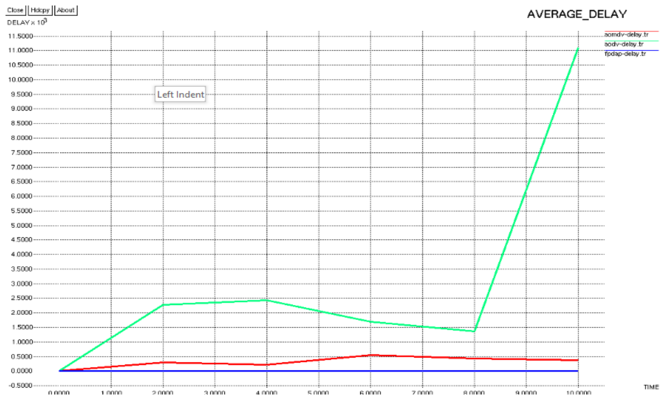

Fig.4 Pause Time vs Average Delay of the Network

Fig.4 shows the delay graph between FPDAP, AODV and AOMDV. FPDAP produce very less delay when compared with the existing AODV and AOMDV protocols.
The comparison of Energy Spent between FPDAP, AODV and AOMDV are given in the figure below.

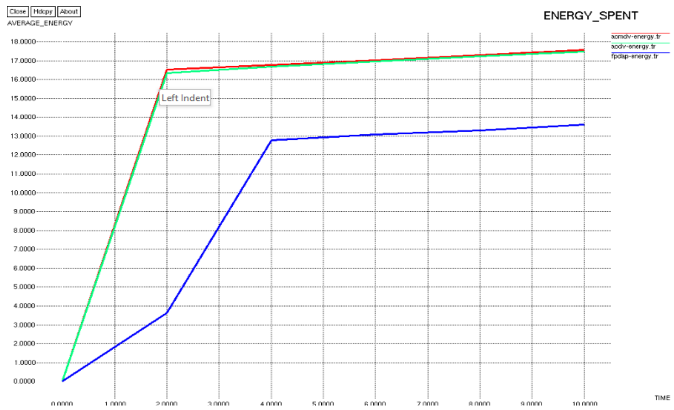

Fig.5 Pause Time vs Energy Spent of the Network

Fig.5 Shows the graph which represents the energy spent of the FPDAP, AODV and AOMDV. The energy spent of the existing AODV and AOMDV approaches are 17.5 percent and 17.6 percent respectively. The energy spent ratio produced by the proposed FPDAP approach is around 13.5 percent which denotes the proposed protocol gains less energy spent when compared with the existing AODV and AOMDV protocols.
The comparison of Packet Delivery Ratio (pdr) between FPDAP, AODV and AOMDV are given in the figure 6.

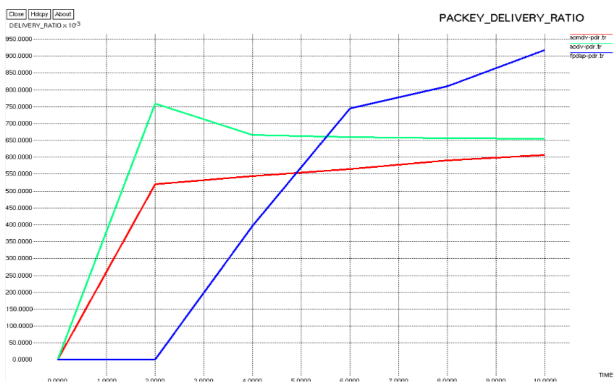

Fig.6 Pause Time vs Packet Delivery Ratio of the Network

Fig.6 shows the graph which denotes the comparison between the simulation time and packet delivery ratio of the FPDAP, AODV and AOMDV. The packet delivery ratio of the existing AODV and AOMDV approaches are 65.0 percent and 60.0 percent respectively. The throughput produced by the proposed FPDAP approach is around 93.0 percent which denotes the proposed protocol gains high packet delivery ratio when compared with the existing AODV and AOMDV protocols.The comparison of Throughput between FPDAP, AODV and AOMDV are given in the figure below.

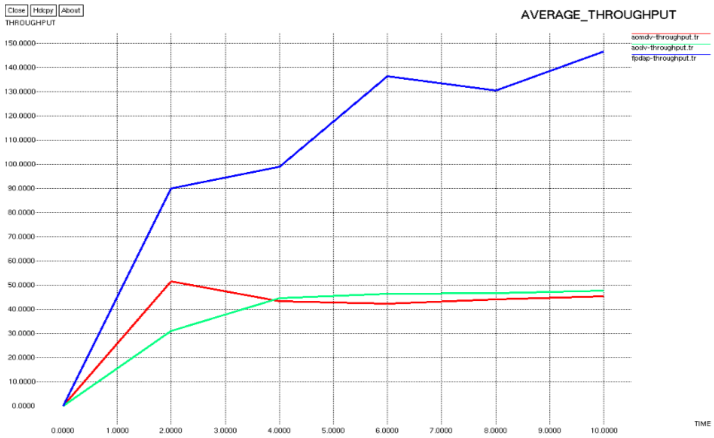

Fig.7 Pause Time vs Average throughput of the Network

Fig.7 shows the graph which depicting the relationship between the simulation time and average throughput of the FPDAP, AODV and AOMDV. The throughput of the existing AODV and AOMDV approaches are 47.0 and 45.0 respectively. The throughput produced by the proposed FPDAP approach is around 147.0 which denotes the proposed approach achieves high throughput ratio when compared with the existing approaches.

V. Conclusion And Future Work

In this paper, a new approach for improving the quality of the ad hoc networks; named Fibonacci sequence based power and delay-aware protocol. The proposed approach finds multiple number of path to convey the data between the sender and the receiver. FPDAP provides maximum throughput, packet delivery ratio (pdr) and minimum delay with consuming minimum energy than existing protocols AODV and AOMDV. We used the packet delivery ratio and the average delay transmission time as benchmarks to learn the performance of the FPDAP approach. The simulation results show that FPDAP protocol has achieved an improvement on packet delivery ratio than other well-known protocols. On the other hand, the FPDAP protocol has scored a lower delay time compared with AODV protocol and AOMDV protocol. Future work includes involving another mathematical method in order to find the best route that reduces the congestion problem. Furthermore, Fuzzy logic techniques can be one of the best choices to dynamically distribute the load over multiple paths.

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