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Fibonacci sequence based multipath load balancing approach for mobile ad hoc networks

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ABSTRACT

This paper explores Fibonacci Multipath Load Balancing protocol (FMLB) for Mobile Ad Hoc Networks (MANETs). The FMLB protocol distributes transmitted packets over multiple paths through the mobile nodes using Fibonacci sequence. Such distribution can increase the delivery ratio since it reduces the congestion. The FMLB protocol's responsibility is balancing the packets transmission over the selected paths and ordering them according to hops count. The shortest path is used more frequently than the other ones. The simulation results show that the FMLB protocol has achieved an enhancement on packet delivery ratio, up to 21%, as compared to the Ad Hoc On-demand Distance Vector routing protocol (AODV) protocol, and up to 11% over the linear Multiple-path routing protocol. Also the results show the effect of nodes pause time and speed on each of the data delivery ratio and End-to-End (E2E) delay transmission time. Finally, the simulation results are obtained by the well-known Glomosim Simulator, version 2.03, without any distance or location measurements devices.

1. Introduction

A Mobile Ad Hoc Network (MANET) is described as an infrastructureless volatile temporary network contains a group of wireless nodes that communicate with each other within a rapidly dynamic topology. In fact, the restrictions on the bandwidth, memory, and energy make MANET a network with complicated topology. One of the most essential characteristics in MANETs is that each node in the network will have two roles at the same time; namely, host role and router role. Ad hoc networks are widely used in the automated battlefields, search and rescue, crowd control, and disaster management [1].

MANET routing is considered as one of the most essential issues that need a scalable mechanism as the network topology and transmitted data may become larger over time [2]. Routing is classified into two main categories: proactive and on-demand single-path routing or multipath routing [2]. Many routing protocols were designed for MANETs such as Ad Hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR) and Temporally Ordered Routing Algorithm (TORA). These three protocols are considered as on demand routing protocols since the routes are formed and optimized upon request [1]. Our study is built upon the Ad hoc on demand distance victor (AODV) routing protocol which chooses only the shortest path in order to transmit data packets. The main disadvantage of using such route is the congestion problem when the network is heavily loaded. It is known that the congestion is one of the most popular factors of packet loss in MANETs [3]. Therefore, multipath based routing protocols rise as a good candidate solution for such problem. However, an algorithm to discover the possible routes and then to distribute data packets optimally over these discovered paths is needed. This motivates our work here in deploying a Load balancing Fibonacci series based algorithm to prevent congestion by distributing the data packets over multiple paths using the Fibonacci sequence.

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Our main contribution in this paper is building an efficient routing protocol that decreases congestion by detecting multiple paths and distributes transmitted packets over these paths using the idea of Fibonacci sequence concept. Such distribution is envisioned to decrease the number of dropped packets and to increase the delivery ratio. This is due to the fact that FMLB promotes using the shortest paths more efficiently and achieving better load balancing as we illustrate in Section 5. Mathematically, Fibonacci sequence is the sequence of numbers that starts with 0, and 1, and each number is the sum of the previous two numbers, as shown by the following equation:

$$\begin{aligned} f_0 &= 0 \\ f_1 &= 1 \\ f_n &= f_{n-2} + f_{n-1}; \quad n \geqslant 2. \end{aligned} \tag{1}$$

This paper is an extension to our initial work which presents in [4] where we introduced the benefits of using Fibonacci sequence. Also, FMLB protocol is compared with AODV in short form. To illustrate the FMLB protocol, suppose that we have seven routes between source and destination node, where these routes are arranged in descending order according to the length of each path. The first path will be the longest path and the seventh path will be the shortest path. For each of these seven paths the corresponding Fibonacci value is assigned and the distributed packets ratio is calculated. Distributed packets ratio is the corresponding Fibonacci value divided by the summation of the corresponding Fibonacci values. The source node starts the distributing of the data packets through the paths according to their weights.

The rest of this paper is outlined as follows: Section 2 introduces the related work. Section 3, the MANET network is described. Glomosim simulator is explained in Section 4. The Fibonacci algorithm and its implementation are explained in Section 5. Section 6 presents the simulation results. Section 7 concludes this work and provides suggestions for future work.

2. Related work

In this section, we briefly review many of the protocols proposed for solving the congestion problem.

In [5], 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. In other words, their approach tracks the quality of all the existing paths in the network topology to a particular destination and then uses the best paths and discards the weak ones which lead to improving the data delivery ratio. However, this approach may compromise the battery's life.

Javan and Dehghan [6] show that some of multipath routing algorithms in MANETs distribute the data packets along the different routes simultaneously using the node-disjoint routes. They pointed out that such approaches suffer from the overlapping between routes (overlapping in medium not in nodes) since the routes in the node-disjoint paths are not independent from each other due to MANETs nature. Thus, sending data packets through a path affects the other paths, so they proposed a new multipath routing algorithm that detects the zone-disjoint routes between any source and destination using Omni-directional antennas. These routes are then used for transmitting data packets. Their simulation results show that their proposed algorithm increases the data delivery ratio and minimize the average of E2E delay in MANETs.

Zone-disjoint algorithm [6] as depicted in Fig. 1, can be explained by the following steps:

1. The source broadcasts a RREQ to its neighbors, for example A, B and C.
2. The nodes A, B and C should ask their neighbors whether they hear this RREQ message or not before broadcasting the RREQ message again.
3. Nodes A and C have just one neighbor that hears the RREQ message which is B for both of them, but node B finds that there are two neighbors hear the RREQ message which is A and B.
4. According to the number of neighbors that hears the message, each of nodes A and C will add a one unit to the ActiveNeighborCount field of its RREQ message, while node B will add two units for the ActiveNeighborCount field of its RREQ message.
5. Then A, B and C nodes will send their RREQ which already has ActiveNeighborCount to their neighbors.
6. Finally the destination node D accepts different RREQs and detects three routes between the source A and the destination D which are: S–A–D, S–B–D and S–C–D these three paths are node-disjoint paths. The destination node chooses two of this routes depends on the least ActiveNeighborCount field value in order to send the RREP massage. S–A–D and S–C–D paths are chosen and called as zone-disjoint paths, since they have the least values of ActiveNeighborCount.

Ahn et al. [7] find the main route using the AODV mechanism, when the primary route is detected, the source node starts sending the data packets over these

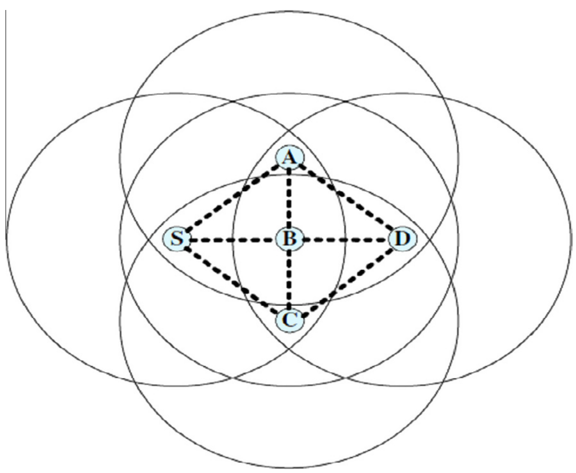

Fig. 1. Zone-disjoint paths [6].