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Mobility and QoS aware anycast routing in Mobile ad hoc Networks ☆

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ABSTRACT

Anycast is an important way of communication for Mobile Ad hoc Networks (MANETs) in terms of resources, robustness and efficiency for replicated service applications. Most of the anycast routing protocols select unstable and congested intermediate nodes, thereby causing frequent path failures and packet losses. We propose a mobility and quality of service aware anycast routing scheme in MANETs (MQAR) that employs three models: (1) node movement stability, (2) channel congestion, and (3) link/route expiry time. These models coupled with Dynamic Source Routing (DSR) protocol are used in the route discovery process to select nearest k-servers. A server among k-servers is selected based on less congestion, route expiry time, number of hops, and better stability. The simulation results indicate that proposed MQAR demonstrates, reduction in control overheads, path delays and improved packet delivery ratio compared to existing methods such as flooding, DSR and load balanced service discovery.

1. Introduction

Mobile Ad hoc Networks (MANETs) consists of a set of wireless mobile nodes communicating to each other without any centralized control or fixed network infrastructure and can be deployed quickly [1,2]. The potential applications include emergency disaster relief, battlefield situations, mine site operations, and wireless classrooms or meeting rooms in which participants wish to share information or to acquire data.

Anycast is an important way of communication for replicated service applications in terms of resources, robustness and efficiency, when mobility and link disconnections are frequent. Anycast allows a source node to transmit packets to a single destination node out of set of several destination nodes. The idea behind anycast is that a client wants to send packets to any one of the nearest possible servers offering a particular service or application. The set of destination nodes is identified by anycast address [3]. As compared to unicast and multicast, anycast is a new type of communication defined in IPv6 that provides a service mainly in client server environment [4].

Constructing and maintaining anycast communication should be simple so as to keep minimum control overheads. It is a common practice in most of the anycast routing protocols, where in packets are sent along the shortest path [5]. This is because, fewer nodes involved in transmission may save the power, network bandwidth and collisions during the message transmission.

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One of the most important issue in MANETs is to find an efficient and reliable anycast route. The current research on MANETs mainly focuses on ad-hoc routing protocols with minimum hop count, energy efficiency, low server load, and low congestion, as the route selection criterion. Although there are many proposed routing protocols for MANETs, most of them consider the shortest-path with minimum hop count as the route selection criterion. Even though hop metric is easy to implement and reliable in dynamic environments, the queuing delay and the contention delay at the intermediate nodes are not taken into account for route selection. Thus, a minimum hop path may sometimes incur a higher end-to-end delay than some alternate paths. Moreover, routing protocols based on minimum number of hops some times cannot fairly distribute the routing load among mobile hosts. An unbalanced distribution of traffic may lead to higher packet dropping rate and faster battery power depletion on certain mobile nodes.

The objective of this paper is to design and analyze a stability and QoS based anycast routing scheme in MANET to improve the performance and enhance the service availability through the method of evenly distributed traffic load. The scheme uses Dynamic Source Routing (DSR) [6] as basic route finding protocol along with stability and QoS models. Our contributions as compared to existing works are as follows. (1) Designing a mathematical model for selecting stable nodes (with respect to position) based on node's own stability, i.e., self stability, and neighbor nodes stability. (2) Designing a mathematical model for selecting noncongested nodes based on channel load and node buffer occupancy. (3) Designing a mathematical model for finding link expiry time between pair of nodes. (4) Design of route discovery process, which includes request phase to find routes to anycast servers through forwarding intermediate nodes which satisfy stability, congestion criteria and also meet the route expiry deadline; and reply phase to update routing cache and confirm the routes found in request phase, and (5) designing route maintenance procedure to handle node and link failures.

The rest of the paper is organized as follows. Section 2 presents an overview of existing MANET anycast routing protocols, Section 3 discusses the proposed work. Simulation and result analysis are presented in Section 4, and conclusions are given in Section 5.

2. Related work

Related works done in the field of anycast routing are presented in this section. Anycast service discovery in MANETs usually relies on network-layer message broadcasting, which leads to large traffic overhead for the scarce bandwidth of MANETs. In Design and implementation of an anycast services discovery (DIASD) [7], traffic-control mechanism is used to balance the load in anycast service discovery, and also supports k-anycast service. With k-anycast service, the fault tolerance and service flexibility is improved. DIASD scheme is used for comparison with our scheme to overcome some of its drawbacks as follows.

DIASD is basically a hierarchical routing protocol, where in prior to the construction of anycast tree, node clustering and virtual backbone are required to organize the nodes in a MANET. Route computation is carried out at the cluster head nodes only; the movement of the cluster nodes adversely affects the performance of the protocol. Also, the cluster node update information could cause a significant amount of control overhead. Thus the main drawback of the tree based protocols is that they are not robust enough to operate in highly mobile environments.

The work presented in [8] introduces anycast method and theory into challenged communication processes in opportunistic network. In [9], IPv6 uses anycast concept and proposes a k-anycast communication model which can route k-anycast service request messages to the nearest k-anycast tree node to provide the requested service, and can evenly distribute across the k-anycast tree nodes.

In [10], authors consider the density of nodes through count of routes to the anycast group member as a routing metric. In [11], a QoS anycast routing algorithm based on ant colony optimization is proposed, which regulates the pheromone on the best path and adopts resetting method and candidate set strategy to avoid falling into local optimal path and expand searching space of ant colony. In [12], Zone Routing Protocol (ZRP) and anycast addressing is presented assuming the destination as a member of anycast address.

The work presented in [13] proposes an Adaptive Neuro-Fuzzy Inference System (ANFIS) based multiple QoS constrained anycast routing by using a set of static and mobile agents. The work given in [14] provides load balancing and failover services in a way that other IT organization teams can use without having to manage the underlying technology.

A Petri-net-based simulation model of a MANET is developed and studied in [15]. The model enables representation of reliability aspects of wireless communication such as fading effects, interferences, presence of obstacles and weather conditions in a general and rather easy way.

The work proposed in [16] is an adaptive congestion aware protocol that detects and reacts to congested nodes and congested parts of the network by using implicit hybrid contact and resources congestion heuristic in delay tolerant networks. In [17], a framework to evaluate network dependability and performability is presented.

In [18], various schemes to improve routing protocol performance by using mobility prediction is presented. To avoid congestion in IP, a backup topology design method is used in [19]. This backup topology design method splits the traffic on high load links to other links by considering network conditions, such as the traffic matrix or topology.

The work given in [20] explores an end-to-end threshold-based algorithm which enhances congestion control to address link failure loss in MANET by using link failures, round trip time and retransmission time out estimation. The work presented in [21] for Limiting Greedy Connections (LGC) uses an active congestion control mechanism for minimizing the degradation in network performance caused by bandwidth greedy applications on a congested node. The work presented in [22] proposes