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On-demand source routing with reduced packets protocol in mobile ad-hoc networks

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ABSTRACT

A mobile ad-hoc network is a collection of nodes forming a dynamic wireless network without pre-existing infrastructure or centralized administration. Mobile ad-hoc network is mostly used in disaster management, military applications, vehicular communication, etc. Each node in the network acts as a router and uses a routing protocol in order to transfer data in a fully distributed way. In this paper, we focus on the routing problematic in mobile ad-hoc networks and we contribute by proposing DS2R2P (on-demand source routing with reduced packets protocol). Our proposal is based on source routing when the source node embeds the route information in the data packet allowing to drive intermediate nodes in order to reach the intended destination. Unlike existing solutions, the header of data packet includes only a reduced integer value instead of the complete sequence of intermediate node addresses. This value is considered as the summary of the routing path and includes a complete information allowing the data packet to reach the destination. We have evaluated the performances of our solution through simulations in which our protocol provides effective results in terms of data routing delay and communication overhead.

1. Introduction

The recent development of wireless communication technology and the emergence of mobile computing prompt active research work granting the access to information anywhere and at any time. Wireless networks are classified into two categories: networks with existing infrastructure and networks without infrastructure. In the first category, the network is based mainly on cellular communications. An access point acts as a router between mobile terminals. Users can move freely without loss of connectivity from an access point to another. In mobile ad-hoc networks [1], the concept of mobility is extended to all components of the network. Unlike cell-based communication networks, no central administration are available and are the mobile nodes themselves that form independently the network infrastructure.

Because of the importance of routing protocols in dynamic multi-hop networks, a lot of routing protocols have been proposed in the literature. There are some challenges that make the design of mobile ad-hoc network routing protocols a hard task. Firstly, in mobile ad-hoc networks, node mobility causes frequent topology changes and network partitions. Secondly, because of the variable and unpredictable capacity of wireless links, packet losses may happen frequently. Moreover, mobile nodes have restricted power, computing and bandwidth resources and require effective routing schemes. Such protocols should guarantee the efficient delivery of data across ad-hoc networks while maintaining a minimum communication overhead, high throughput and low end-to-end delay. The designer should consider bandwidth constraints of the wireless links, fading, interference, packet loss, exhaustible energy supply, limited computing capabilities, and a dynamic topology [5]. Existing solutions are classified mainly in two categories of protocols: proactive and reactive. In proactive routing protocols, each node in the network maintains a routing table for the broadcast of the data packets and want to establish connection to other nodes in the network. These nodes record for all the presented destinations, number of hops required to reach each destination in the routing table. To retain the stability, each node broadcasts and modifies its routing table periodically which involves a high overhead. A reactive protocol generates lower overhead since routes are determined on-demand. It searches for the route in an on-demand manner and set the link in order to send out and accept the packet from a source node to a destination node. Route discovery process is used by flooding the route request packets throughout the network [4]. In this paper, we focus on the category of reactive routing

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protocols and we contribute to this understanding by proposing DS2R2P (on-Demand Source Routing with Reduced Packets Protocol). Our proposal is based on source routing when the source node embeds the route information in the data packet allowing to drive intermediate nodes in order to reach the intended destination. Mobile nodes exchange control packets, as the request packet, the response packet and the error packet. Unlike existing solutions, the header of data packet includes only a reduced integer value instead of the complete sequence of intermediate node addresses. This value is considered as the summary of the routing path and includes the complete information allowing the data packet to reach the route destination.

The rest of this paper is organized as follows. In Section 2, we present the related work. In Section 3, we present a detailed description of our protocol. In Section 4, we present the performance analysis of our protocol. Finally, we conclude the paper in Section 5.

2. Related work

Routing protocols in mobile ad-hoc networks may be categorized into three classes: proactive routing protocols, reactive routing protocols and hybrid protocols [3]. We suggest to the reader a very useful and comprehensive survey in [7]. In the literature they are a huge number of solutions of routing in mobile ad-hoc networks. In this paper, we focus on the category of reactive protocols and in grand part the solutions based on source routing, in which we present some relevant protocols. Whenever there is a need of a path from any source to the destination then a type of query reply dialog does the work. Therefore, the latency is high; however, no unnecessary control messages are required. Dynamic source routing protocol (DSR) [9,11] is a source-routed on-demand routing protocol. A node maintains route caches containing the source routes that it is aware of. The route request packet contains the address of the source and the destination. Upon receiving this packet, each intermediate node checks whether it knows of a route to the destination. If it does not, it appends its address to the route record of the packet and forwards the packet to its neighbors. A route reply is generated when either the destination or an intermediate node with current information about the destination receives the route request packet. A route request packet reaching such a node already contains, in its route record, the sequence of hops taken from the source to this node. Ad-hoc On-demand Distance Vector Routing (AODV) [13] minimizes the number of broadcasts by creating routes on-demand. To find a path to the destination, the source broadcasts a route request packet. The neighbors in turn broadcast the packet to their neighbors till it reaches an intermediate node that has a recent route information about the destination or till it reaches the destination . When a node forwards a route request packet to its neighbors, it also records in its tables the node from which the first copy of the request came. This information is used to construct the reverse path for the route reply packet. AODV uses only symmetric links because the route reply packet follows the reverse path of the route request packet. As the route reply packet traverses back to the source, the nodes along the path enter the forward route into their tables. Location-aided routing (LAR) [12] proposes the use of position information to enhance the route discovery phase of reactive ad-hoc routing approaches. Reactive ad-hoc routing protocols frequently use flooding as a means of route discovery. Under the assumption that nodes have information about other node positions, this position information can be used by LAR to restrict the flooding in a certain area. Ad-hoc on-demand QoS routing based on bandwidth prediction (AQBP) [2] takes node future bandwidth into consideration when selects a route. The future bandwidth requirement of each node is predicted by its history. Multi Route AODV-Ant routing Algorithm (MRAA) [8] proposes two methods to improve the AODV protocol. The main goal in the design of the protocol was to reduce the routing overhead, buffer overflow and end-to-end. A multi-path routing protocol is proposed which is based on AODV and Ant colony optimization (ACO). Moreover, it integrates a load balancing method that uses all discovered paths simultaneously for transmitting data. In this method, data packets are balanced over discovered paths and energy consumption is distributed across many nodes through the network. Hash-based dynamic source routing (HB-DSR) [10] proposes to compress the list of addresses. Instead of including a source-routing option in each data packet, the source node insert the corresponding Bloom filter. HB-DSR reserves 3 bytes in the case of IPv4 and 4 bytes in the case of IPv6. HB-DSR improves DSR in terms of overhead, however the size of data packet header still remains considerable. Moreover, the problem of collision generates further overhead in terms of communication. EST-based automatic route shortening (EST-ARS) [6] introduces the so-called expected sending times (EST) to evaluate the quality of links, which is used to perform an automatic route shortening process. The EST of a link is considered as the expected number of data transmissions required to send a packet over that link. The EST of a route is the sum of the EST for each link in the route. The calculation of links EST is performed using hello packets, and a low value of EST means that it consumes less time and energy to send a packet successfully, and vice versa. Obviously, the smaller EST of a link is, the better the link quality. After a node outside source route overheard a data packet, if it finds that there is a shorter route to the destination node of the packet in its own route cache, it should return a request of routing comparison, which gives the full path to the original node. Then, the source node will launch the comparison process about the values of EST of the original route and the candidate route.

3. Our protocol

In this section, we present our routing protocol entitled DS2R2P (on-Demand Source Routing with Reduced Packets Protocol). We model the considered environment and then, we give a detailed description of the elements composing DS2R2P.

3.1. Network model

We consider mobile ad-hoc networks where a set of ∂ mobile nodes are randomly located in a two-dimensional space and move with a random mobility pattern, i.e., nodes moving independently. Each node υ_i has a single channel and hence, we will use the same identifier for the node and its address. The network topology changes frequently due to the mobility of nodes. We assume that mobile nodes have the same transmission power range ρ. The set of nodes in the υ_i's vicinity denoted by Θ_i, consists of υ_i's neighboring nodes, defined as: $\Theta_i = \{\upsilon_j : d_{(\upsilon_i,\upsilon_j)} \leq \rho\}$, where $d_{(\upsilon_i,\upsilon_j)}$ denotes the Euclidean distance between nodes υ_i and υ_j. We note that the communication links are bidirectional, i.e., if $\upsilon_j \in \Theta_i$ then, $\upsilon_i \in \Theta_j$. The network can be modeled by a graph $G = (V, E)$, where V is the set of all nodes and E is the set of all direct links. There is an edge between two nodes if they are located within each other transmission range. A path between the source node υ_S and the destination node υ_D can be represented as a node sequence $R = (\upsilon_S, \ldots, \upsilon_i, \ldots, \upsilon_D)$, where $\upsilon_i \in V$.

3.2. Overview of DS2R2P

DS2R2P operates in two main phases: route discovery and data packet routing. Route discovery is started before transmitting a data