DESIGN AND IMPLEMENTATION OF ENERGY EFFICIENT AND SECURE ROUTING PROTOCOL IN MANET's

Shivani Bansal
Research Scholar

ABSTRACT

The structure of the Internet that is used today is based mainly on wired communications. The emerging technologies like fiber optics–based high speed wired networks would flourish in the near future. With this existing network of networks, semi-infrastructure and infrastructure-less wireless networks will also be used in abundance. Figure 4 shows a conceptual view of the future global Internet structure. MANETs would definitely play an important role in the future Internet structure, especially for the mobile Internet. Hence, in some cases, it might be necessary that the routing protocols of MANET work in perfect harmony with their wired counterparts. Considering different approaches of routing, a hybrid approach might be more appropriate for such scenarios.

Keywords: Routing Protocols, Mobile ad-hoc Network, DSDV, Associatively Based Routing

INTRODUCTION

A mobile ad hoc network (MANET) is built on the fly where a number of mobile nodes work in cooperation without the engagement of any centralized access point or any fixed infrastructure. MANETs are self-organizing, self-configuring, and dynamic topology networks, which form a particular class of multi-hop networks. Minimal configuration, absence of infrastructure, and quick deployment make them convenient for combat, medical, and other emergency situations. A sample model of mobile ad hoc network is presented here in Fig. 1,

Fig. 1 An Example of Mobile Ad hoc Network (MANET)

Properties of Routing Protocols

A routing protocol for MANET should be distributed in manner in order to increase its reliability. Where all nodes are mobile, it is unacceptable to have a routing protocol that requires a centralized entity. Each node should be intelligent enough to make routing decisions using other collaborating nodes. A distributed but virtually centralized protocol might be a good idea.

- The routing protocol should assume routes as unidirectional links.
- The routing protocol should be power-efficient.
- The routing protocol should consider its security.
- Hybrid protocols, which combine the benefits of different routing protocols, can be preferred in most of the cases.

Categorizing of Routing Protocols

The routing protocols for MANET could be broadly classified into two major categories: Proactive Routing Protocols and Reactive Routing Protocols

1. **Proactive Routing Protocols**

Proactive protocols continuously learn the topology of the network by exchanging topological information among the network nodes. Thus, when there is a need for a route to a destination, such route information is available immediately. The main concern regarding using a proactive routing protocol is: if the Routing in Mobile Ad Hoc Networks network topology changes too frequently, the cost of maintaining the network might be very high.

2. **Reactive Routing Protocols**

The reactive routing protocols, on the other hand, are based on some sort of query-reply dialog. Reactive protocols proceed for establishing route(s) to the destination only when the need arises or *on demand* basis. Reactive protocols are also known as on-demand routing protocols.

3. **Hybrid Routing Protocols**

Often reactive or proactive feature of a particular routing protocol might not be enough; instead a mixture might yield better solution. Hence, in the recent days, several hybrid protocols are also proposed. The hybrid protocols include some of the characteristics of proactive protocols and some of the characteristics of reactive protocols.

LITERATURE REVIEW

Many routing protocols have been designed and reported in the literature so far we have listed few of them according to the various category of protocols.

1. **Proactive Routing Protocols**

(B) Dynamic Destination-Sequenced Distance-Vector Routing Protocol(DSDV)

DSDV [7] is developed on the basis of Bellman–Ford routing [8] algorithm with some modifications. In this routing protocol, each mobile node in the network keeps a routing table. Each of the routing table contains the list of all available destinations and the number of hops to each. Each table entry is tagged with a sequence number, which is originated by the destination node.

(C) Wireless Routing Protocol

Wireless Routing Protocol (WRP) [9] belongs to the general class of path-finding algorithms [8, 10, 11], defined as the set of distributed shortest-path algorithms that calculate the paths using information regarding the length and second-to-last hop of the shortest path to each destination.

(D) Cluster Gateway Switch Routing Protocol

Cluster Gateway Switch Routing Protocol (CGSR) [12] considers a clustered mobile wireless network instead of a ‘‘flat’’ network. For structuring the network into separate but interrelated groups, cluster heads are elected using a cluster head selection algorithm. By forming several clusters, this protocol achieves a distributed processing mechanism in the network. However, one drawback of this protocol is that, frequent change or selection of cluster heads might be resource hungry and it might affect the routing performance.

(E) Global State Routing

In Global State Routing (GSR) protocol [13], nodes exchange vectors of link states among their neighbors during routing information exchange.

(F) Fisheye State Routing

Fisheye State Routing (FSR) [14] is built on top of GSR. The novelty of FSR is that it uses a special structure of the network called the ‘‘fisheye.’’ This protocol reduces the amount of traffic for transmitting the update messages. The basic idea is that each update message does not contain information about all nodes. Instead, it contains update information about the nearer nodes more frequently than that of the farther nodes. Hence, each node can have accurate and exact information about its own neighboring nodes.

(G) Hierarchical State Routing

Hierarchical State Routing (HSR) [14] combines dynamic, distributed multilevel hierarchical clustering technique with an efficient location management scheme. This protocol partitions the network into several clusters where each elected cluster head at the lower level in the hierarchy becomes member of the next higher level.

(H) Zone-Based Hierarchical Link State Routing Protocol

In Zone-Based Hierarchical Link State Routing (ZHLS) protocol [15], the network is divided into non-overlapping zones as in cellular networks. Each node knows the node connectivity within its own zone and the zone connectivity information of the entire network.

(I) Landmark Ad Hoc Routing

Landmark Ad hoc Routing (LANMAR) [16] combines the features of Fisheye State Routing (FSR) and Landmark Routing [17]. It uses the concept of landmark from Landmark Routing, which was originally developed for fixed wide area networks.

(J) Optimized Link State Routing

Optimized Link State Routing (OLSR) [18] protocol inherits the stability of link state algorithm. Usually, in a pure link state protocol, all the links with neighbor nodes are declared and are flooded in the entire network. But, OLSR is an optimized version of a pure link state protocol designed for MANET.

2. Reactive Routing Protocols

(A) Associativity-Based Routing

Associativity-Based Routing (ABR) [19] protocol defines a new type of routing metric for mobile ad hoc networks. This routing metric is termed as degree of association stability. Each node periodically generates beacon to announce its existence. Upon receiving the beacon message, a neighbor node updates its own associability table. For each beacon received, the associativity tick of the receiving node with the beaconing node is increased. A high value of associativity tick for any particular beaconing node means that the node is relatively static. Associativity tick is reset when any neighboring node moves out of the neighborhood of any other node. ABR protocol has three phases for the routing operations:

- Route discovery
- Route reconstruction
- Route deletion

(B) Signal Stability–Based Adaptive Routing Protocol

Signal Stability–Based Adaptive Routing (SSA) [20] protocol focuses on obtaining the most stable routes through an ad hoc network. The protocol performs on-demand route discovery based on signal strength and location stability. Based on the signal strength, SSA detects weak and strong channels in the network.

(C) Temporarily Ordered Routing Algorithm

Temporally Ordered Routing Algorithm (TORA) [21] is a reactive routing protocol with some proactive enhancements where a link between nodes is established creating a Directed Acyclic Graph (DAG) of the route from the source node to the destination. This protocol uses a ''link reversal'' model in route discovery. A route discovery query is broadcasted and propagated throughout the network until it reaches the destination or a node that has information about how to reach the destination. TORA defines a parameter, termed height. Height is a measure of the distance of the responding node's distance up to the required destination node.

(D) Cluster-Based Routing Protocol

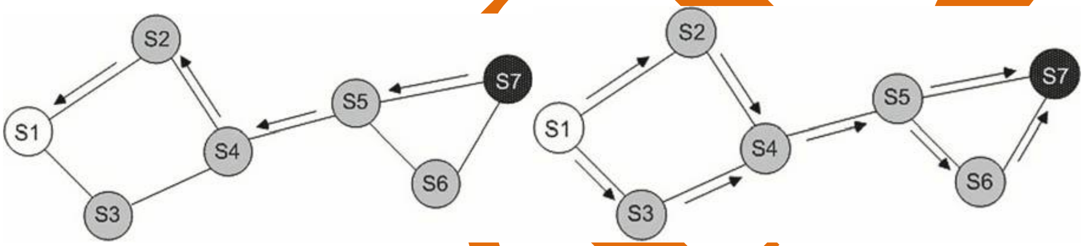
Cluster-Based Routing Protocol (CBRP) [22] is an on-demand routing protocol, where the nodes are divided into clusters. For cluster formation, the following algorithm is employed. When a node comes up in the network, it has the undecided state. The first task of this node is to start a timer and to broadcast a HELLO message. When a cluster-head receives this HELLO message, it replies immediately with a triggered HELLO message. After that, when the node receives this answer, it changes its state into the member state. But when the node gets no message from any cluster-head, it makes itself as a cluster-head, but only when it has bidirectional link to one or more neighbor nodes. Otherwise, when it has no link to any other node, it stays in the undecided state and repeats the procedure with sending a HELLO message again

(E) Dynamic Source Routing

Dynamic Source Routing (DSR) [23] allows nodes in the MANET to dynamically discover a source route across multiple network hops to any destination. In this protocol, the mobile nodes are required to maintain route caches or the known routes. The route cache is updated when any new route is known for a particular entry in the route cache. Routing in DSR is done using two phases: *route discovery and route maintenance*. When a source node wants to send a packet to a destination, it first consults its route cache to determine whether it already knows about any route to the destination or not. If already there is an entry for that destination, the source uses that to send the packet. If not, it initiates a 0 route request broadcast. This request includes the destination address, source address, and a unique identification number. Each intermediate node checks whether it knows about the destination or not. If the intermediate node does not know about the destination, it again forwards the packet and eventually this reaches the destination. A node processes the route request packet only if it has not previously processed the packet and its address is not present in the route record of the packet. A route reply is generated by the destination or by any of the intermediate nodes when it knows about how to reach the destination.

(F) Ad Hoc On-Demand Distance Vector Routing

Ad Hoc On-Demand Distance Vector Routing (AODV) [24] is basically an improvement of DSDV. But, AODV is a reactive routing protocol instead of proactive. It minimizes the number of broadcasts by creating routes based on demand, which is not the case for DSDV. When any source node wants to send a packet to a destination, it broadcasts a route request (RREQ) packet. The neighboring nodes in turn broadcast the packet to their neighbors and the process continues until the packet reaches the destination. During the process of forwarding the route request, intermediate nodes record the address of the neighbor from which the first copy of the broadcast packet is received. This record is stored in their route tables, which helps for establishing a reverse path. If additional copies of the same RREQ are later received, these packets are discarded. The reply is sent using the reverse path. For route maintenance, when a source node moves, it can re-initiate a route discovery process. If any intermediate node moves within a particular route, the neighbor of the drifted node can detect the link failure and sends a link failure notification to its upstream neighbor. This process continues until the failure



(a) **(b)**

Fig.2 AODV protocol (a) Source node broadcasting the route request packet. (b) Route reply is sent by the destination using the reverse path notification reaches the source node. Based on the received information, the source might decide to re-initiate the route discovery phase.

3. Hybrid Routing Protocols

(a) Dual-Hybrid Adaptive Routing

Dual-Hybrid Adaptive Routing (DHAR) [25] uses the Distributed Dynamic Cluster Algorithm (DDCA) presented in [26]. The idea of DDCA is to dynamically partition the network into some non-overlapping clusters of nodes consisting of one parent and zero or more children. Routing is done in DHAR utilizing a dynamic two-level hierarchical strategy, consisting of optimal and least-overhead table-driven algorithms operating at each level.

(b) . Adaptive Distance Vector Routing

Adaptive Distance Vector (ADV) [27] routing protocol is a distance-vector routing algorithm that exhibits some on-demand features by varying the frequency and the size of routing updates in response to the network load and mobility patterns. This protocol has the benefits of both proactive and reactive routing protocols.

(c) Zone Routing Protocol

Zone Routing Protocol (ZRP) [28] is suitable for wide variety of MANETs, especially for the networks with large span and diverse mobility patterns. In this protocol, each node proactively maintains routes within a local region, which is termed as routing zone. Route creation is done using a query-reply mechanism.

(d) Sharp Hybrid Adaptive Routing Protocol

Sharp Hybrid Adaptive Routing Protocol (SHARP) [30] combines the features of both proactive and reactive routing mechanisms. SHARP adapts between reactive and proactive routing by dynamically varying the amount of routing information shared proactively. This protocol defines the proactive zones around some nodes. The number of nodes in a particular proactive zone is determined by the node-specific zone radius. All nodes within the zone radius of a particular node become the member of that particular proactive zone for that node.

(e) Neighbor-Aware Multicast Routing Protocol

Neighbor-Aware Multicast Routing Protocol (NAMP) [31] is a tree-based hybrid routing protocol, which utilizes neighborhood information. The routes in the network are built and maintained using the traditional request and reply messages or on-demand basis. This hybrid protocol uses neighbor information of two-hops away for transmitting the packets to the receiver. If the receiver is not within this range, it searches the receiver using dominant pruning flooding method [32] and forms a multicast tree using the replies along the reverse path.

PROBLEM STATEMENT

Criteria for Performance Evaluation of MANET Routing Protocols

We generally take some common criteria as the basis of comparison. Commonly used criteria are the end-to-end delay, control overhead, processing overhead of nodes, memory requirement, and packet-delivery ratio. Of these criteria, packet-delivery ratio mainly tells about the reliability of the protocol. So, reliability of a routing protocol depends on how efficiently it can transmit data from source to the destination. The less the packet loss ratio is, the better the performance of that routing protocol. Often security becomes the key aspect of MANET. In such cases, the protocol that might ensure better security is considered as more efficient for that application. Having the knowledge of the MANET routing protocols and their comparison criteria, let us now investigate the key influencing factors for routing performance in different settings of MANETs.

Mobility Factors

- Velocity of nodes
- Direction of mobility
- Group or individual mobility
- Frequency of changing of mobility model

Wireless Communication Factors

(a) Consumption of power: Power is a valuable resource in wireless networking. Especially for routing, power is highly needed. According to an experiment by Kravets and Krishnan (1998), power consumption caused by networking related activities is approximately 10% of the overall power consumption of a laptop computer. This figure rises up to 50% in handheld devices [71]. In ad hoc network, every node has to contribute for maintaining the network connections. Hence, routing protocol should consider everything to save power of the participating battery-powered devices.

(b) Bandwidth: For any type of wireless communications, bandwidth available for the network is a major concern. An efficient routing protocol should try to minimize the number of packet-transmissions or control overhead for the maintenance of the network.

(c) Error rate: Wireless communication is always susceptible to high error rate. Packet loss is a common incident. So, the routing strategies should be intelligent enough to minimize the error rate for smooth communications among the nodes.

(d) Unidirectional link: Sometimes it is convenient for a routing protocol to assume routes as unidirectional links.

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