Comprehensive Study of Routing Protocols and Power Saving in Cluster Based AODV-ERS Protocol

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Abstract— Wireless adhoc networks are a new type of wireless network which can communicate to each other without infrastructure base stations. Battery power is a vital resource in ad hoc networks. In ad hoc networks, energy consumption does not reveal the communication activities in the network. However, due to restricted power, routing path is broken easily, so how to design an effective power saving routing protocol is an important issue in wireless ad hoc networks. In this review paper we give a brief overview of various routing protocols and also compare the clustering based power saving Directional Local Repairing (DLR) method with AODV-ERS protocol with respect to power consumption and number of dead nodes.

Keywords – Adhoc Networks, Routing Protocols, AODV, ERS, DLR

I. INTRODUCTION

With the explosion of portable computing platforms and small wireless devices, adhoc wireless networks have received more and more attention as a means for providing data communications among devices regardless of their physical locations. The advantage of Wireless communication is that it allows untethered communication, which implies reliance on portable power sources such as batteries. Among the various network architectures, the design of mobile ad hoc network (MANET) has attracted a lot of attention recently. A MANET consists of a set of mobile hosts which can communicate with one another and roam around at their will. No base stations are supported in such an environment, and mobile hosts communicate with each other in a multihop fashion. Applications of MANETs occur in situations like battlefields, major disaster areas, and outdoor assemblies. One critical issue for all kinds of portable devices supported by battery power is power saving. However, due to the slow development in battery technology, battery power is a constrained resource and so power management in wireless networks remains to be an important issue. Power management in ad hoc networks is a more difficult problem due to two reasons. Firstly, in ad hoc networks, a node can act both as a data source/sink and a router that forwards data for other nodes and participates in high-level routing and control protocols. Also, the roles of a particular node may change over time. Secondly, there is no centralized entity such as an access point to control and maintain the power management mode of each node in the network. Therefore, power management in ad hoc networks must be done in a distributed and cooperative fashion. The power saving issue in MANET can be resolved by parameters like transmission power control, power aware routing and low power mode. In this paper, we discuss the various routing protocols and compare the cluster based DLR routing which is an improvement over AODV-ERS routing in terms of power consumption and number of dead nodes.

II. Classification of Routing Protocol

(i) Communication Model
Protocols can be divided according to communications model that are designed for multi-channel or single-channel communications.

(ii) Structure
Protocols can be divided into Uniform and Non Uniform Routing Protocols. Structure of a network can be classified according to node uniformity.

(iii) Type of Cast
Protocols operate at unicast, multicast, or geocast situations.

(v) Scheduling
The information from source to destination can be obtained continuously or it can be triggered only by on demand. The protocols can be divided into the following types:

(a) Proactive (Table-Driven)-Proactive protocols, also known as table-driven protocols, maintain all the time routing information for all known destinations at every source. In these protocols nodes exchange route information periodically and / or in response to topology...
change. They have the advantage that communication with arbitrary destinations experience minimal delay from the point of view of the application. When the application starts, a route can be immediately selected from the route table. They are called pro-active as they store routing information even before it is needed. They are called table driven as routes are available as a part of well maintained table.

(b) Reactive (On-Demand) - In on-demand or reactive protocols, the route is only calculated on demand basis. This ensures that there is no unnecessary routing information maintained. The route calculation process is divided into a route discovery and a route maintenance phase. The route discovery process is initiated when a source needs a route to a destination. The route maintenance process deletes failed routes and re-initiates route discovery in the case of topology change. They are also known as Source-Initiated protocols.

(c) Hybrid-Mobile wireless networks differ in the frequency and degree at which the topology changes. Therefore, a protocol that works well in one MANET may not work well in another with a different density or size. The diverse applications of adhoc networks pose a challenge for a single protocol that operates efficiently across a wide range of operational conditions and network configuration. This issue of efficient operation over a wide range of conditions can be addressed by a hybrid routing protocol, where pro-active and reactive behavior is mixed in the amounts that best match these operational conditions.

III. Overview of Routing Protocols

3.1 Topology based Protocols

(i) Global State Routing (GSR): GSR[1] is a uniform, pro-active, topology based routing protocol. It is a variation of traditional link-state protocols, in which each node sends link-state information to every node in the network every time its connectivity changes. GSR reduces the cost of disseminating link-state information by relying on periodic exchange of sequenced data rather than flooding. In GSR, each node periodically broadcasts its entire topology table to its immediate neighbors. Based on the complete topology information in the topology table, any shortest-path algorithm can be used to compute a routing table containing the optimal next-hop information for each destination.

3.2 Destination based protocols

(i) Wireless routing protocol (WRP)

WRP [2] belongs to the general path of path finding algorithms that calculate shortest path routes using the length and the second-to-last hop (predecessor) of the path to the destination. Each node maintains four tables.

(a) Distance table

(b) Routing table

(c) Link-cost table

(d) Message retransmission (MRL) table. Part of the novelty of WRP stems from the way in which it achieves loop freedom. In WRP, routing nodes communicate the distance and second-to-last hop information for each destination in the wireless networks. WRP belongs to the class of path-finding algorithms with an important exception. It avoids the “count-to-infinity” problem by forcing each node to perform consistency checks of predecessor information reported by all its neighbors. This ultimately eliminates looping situations and provides faster route convergence when a link failure event occurs. The main drawback of WRP seems to be the requirement for nodes to maintain four routing tables as well as the use of updates and HELLO messages which leads to substantial memory requirements when the number of nodes in the network is large.

3.3 Neighbour selection protocols

(i) Optimized Link State Routing Protocol (OLSR)

OLSR [3] is an optimization over the classical link state protocol as it reduces the size of information sent in each message and also reduces the total control overhead by minimizing the number of retransmissions flooding an entire network. It comes under the class of pro-active routing protocol. It employs periodic exchange of messages to maintain topology information of the network at each node. This protocol is best suited for dense and large ad hoc networks. It uses a multipoint relaying technique to flood the control messages in the network in an efficient manner. This is achieved with the use of multi point relay (MPR) nodes.

(ii) Fisheye State Routing (FSR)

FSR [4,5] is a hierarchical routing protocol which aims at reducing control packet overhead by introducing the multilevel scopes. It is essentially a table driven protocol that implements the fisheye technique which is very effective to reduce the size of information required to represent graphical data. It uses the concept that the eye of a fish captures with greater detail the view nearer to the focal point while detail decreases as the distance from the focal point increases. Fisheye Source Routing is based on a method to divide each node’s neighborhood to blurred zones so that the information details and accuracy is better for near nodes. The foremost benefit is the reduction of message size, since the routing information of the far away node is omitted. With an increase in size of the network, a graded frequency update plan can be adopted across scopes to minimize the overall overhead. This protocol scales well to large size of networks while keeping the control overhead low without compromising on the accuracy of routes calculations. Routes to farther destinations may seem stale; however, they become increasingly accurate as a packet approaches its destination.

3.4 Proactive routing protocol

(i) Distance Source Distance Vector (DSDV) Routing Protocol

The Distance Sequenced Distance Vector (DSDV) routing protocol is a table-driven routing protocol based on Bellman–Ford routing algorithm. Every node in the network maintains a routing table that contains all the possible destinations as well as numbers of hops to reach the destination are
recorded. Each route entry is marked with a sequence number; they are assigned by the destination node and are called destination sequence number. Routing updates are periodically sent throughout the network to maintain routing table consistency. Route updates consist of the address of the destination node, the number of hops to reach the destination, the destination sequence number as well as the sequence number that exclusively identifies the update. DSDV primarily is a distance vector protocol but minor changes have to be made to make it appropriate for adhoc network applications. Nodes send scheduled updates to its neighbor to keep the informed about the network. In addition to scheduled updates, triggered updates are also sent when there is a change in topology. DSDV is less efficient due to the requirement for periodic update transmissions irrespective of the number of changes as well as active data sources in the network topology.

(ii) Source –Tree Adaptive Routing (STAR)
Source-Tree Adaptive Routing (STAR)[7] was the first pro-active routing protocol to work with link state protocol. Link state protocol uses topology information to take routing decisions. Every node maintains a source tree which contains preferred links to all possible destinations. Neighbor source trees exchange information to maintain up-to-date tables. A route selection algorithm is run depending on the topology information sent to the neighbors. The routing table includes entries for the destination node and the next hop neighbor. In this protocol, no periodic updates are needed. Instead, link state update (LSU) messages are used to update changes of the routes in the source trees which do not experience time out.

(iii) Topology Broadcast Based on Reverse Path Forwarding (TBBRPF)
Topology Broadcast based on reverse path forwarding [8,9] is a proactive, link state routing protocol designed for mobile adhoc networks and provides hop by hop routing along minimum hop path to each destination. Each node running TBBRPF computes a source tree (providing paths to all possible destinations) based on partial topology information stored in its topology table, using a modification of Dijkstra’s algorithm. To minimize overhead, each node reports only part of its source tree to neighbors. This is in contrast to other protocols (e.g., STAR) in which each node reports its entire source tree to neighbors. TBBRPF adapts to topology change faster, generates less routing overhead and uses smaller topology update packet size than pure link state protocols.

3.5 Reactive (On Demand) Routing Protocol or Source Initiated Routing Protocol
(i) Dynamic Source Routing
Dynamic Source Routing[10] is one of the most widely used source routing algorithm and has a route discovery and route maintenance phase. Each packet carries in its header the complete ordered list of nodes the packet should pass through in the network. This is achieved by having each node maintain a cache with source routes to destinations. The DSR protocol is composed of two mechanisms namely, Route Discovery and Route Maintenance each operating entirely on demand. DSR unlike other protocols requires no periodic packets of any kind at any level within the network. The entirely on-demand behavior and lack of periodic activity causes the number of overhead packets to scale down to zero in case of stationary nodes or scale to only that needed to track the routes currently in use, when the nodes are mobile. DSR also allows nodes to keep multiple routes to a destination in their cache. Hence, when a link on a route is broken, the source node can check its cache for another valid route. If such a route is found route construction need not be invoked thus saving network bandwidth.

(ii) Associativity based routing (ABR) protocol
ABR[11] is a source-initiated routing protocol, which means that there is no need for periodic route updates. ABR selects route based on the temporal stability of the links between the nodes. ABR is beacon-based, so that each node generates periodic beacons (hello messages) to signify its existence to the neighbors. In ABR, the key selection criterion is the longevity of the routes instead of the route length; this metric is known as the degree of association stability. These beacons are used to update the associativity table of each node. The major benefit of ABR relies on the longevity concept of routes. It also relies on periodic beaconing. The beaconing interval should be short enough to accurately reflect the spatial, temporal, and connectivity state of the nodes. This results in additional network overhead and power consumption.

(iii) Temporally Ordered Routing Algorithm (TORA)
TORA[12] belongs to a general family of link reversal algorithms. It is highly adaptive, scalable and efficient distributed routing algorithm. TORA also comes under flat, non-hierarchical routing algorithm. The algorithm tries to suppress to the greatest extent, the generation of far reaching control message propagation. In order to achieve this, TORA builds and maintains a Directed Acyclic Graph rooted at the destination instead of using shortest path. No two nodes can have the same height. Information may flow from nodes with higher heights to nodes with lower heights. Information can therefore be thought of as a fluid that may only flow downhill. By maintaining a set of totally-ordered heights at all times, TORA achieves loop-free multipath routing, as information cannot ‘flow uphill’ and so cross back on itself. Thus significant network bandwidth saving results as route rebuilding is less as route reconstruction is not necessary until all known routes to the destination are considered invalid.

(iv) Signal Stability routing (SSR) protocol
Signal Stability routing(SSR) protocol[13] differs from conventional routing algorithm since the main routing depends on signal and location stability. The SSR is comprised of two sub protocols: Dynamic Routing Protocol (DRP) and Static Routing Protocol (SRP). The SSR algorithm uses a similar scheme as the ABR algorithm to determine the reliability of links before
selecting a particular route. While the former uses the signal strength, the latter uses ticks; though the goal of selecting a route with greatest consistency remains the same.

(v) Lightweight Mobile Routing (LMR)

The Lightweight Mobile Routing Protocol [14] is another source initiated and on demand routing protocol using a flooding technique to determine its route. LMR belongs to the class of Link Reversal algorithm. The LMR algorithm is distributed and deadlock-free, and maintains routes that are loop-free at all times to each desired destination. The protocol works independent of the number and location of topological changes even if the network is partitioned. The protocol is localized as the nodes do not maintain global connectivity information but are aware of only connections to neighboring nodes. In addition to this, LMR protocol adapts to topological changes with minimum amount of overhead and maintains multipath routing only between desired source destination pairs. The LMR protocol sacrifices routing quality under light traffic conditions to reduce complexity.

3.6 Hierarchical Routing

(i) Cluster head-Gateway Switch Routing (CGSR)

Cluster head-Gateway Switch Routing (CGSR) [15] comes under hierarchical network which classifies nodes on priority bases. The entire network is separated into sectors, similar to circles in a mobile network. In each of the divided sectors of the networks, one node is giving higher responsibility and functionalities to maintain the routing tables of that particular sector. CGSR protocol is a clustering scheme that uses a distributed algorithm called the Least Cluster Change (LCC). Nodes aggregated into clusters, controlled by cluster heads create a framework for developing additional features for channel access, bandwidth allocation and routing.

(ii) Hierarchical State Routing (HSR)

Hierarchical State Routing (HSR) [16] is a typical example of a hierarchical routing protocol. HSR maintains a hierarchical topology, where elected clusterheads at the lowest level become members of the next higher level. Superclusters are formed on the higher level and so on.

3.7 Hybrid Protocol

(i) Zone Routing Protocol

Zone Routing Protocol [17] is a well-known hybrid routing protocol, most suitable for large scale networks. ZRP divides the network into various routing zones. ZRP uses a pro-active mechanism of node discovery within a nodes immediate neighbourhood, while interzone communication is carried out by using reactive approaches. ZRP works on the principle that node communication in adhoc networks is localized and thus changes in node topology in the neighbouring nodes are important. Since ZRP is a hybrid of proactive and reactive schemes, routes can be found very fast within the routing zone while routes outside the zone can be found by efficiently querying selected nodes in the network.

(ii) Landmark Adhoc Routing Protocol (LANMAR)

LANMAR [18] protocol combines link state and distance vector algorithms to build subnets of group of nodes which can move together. A landmark node is elected in each subnet and LANMAR routing table is maintained which consists of landmark nodes and only those nodes which are within its scope. LANMAR reduces both routing table size and control overhead through the truncated local routing table and summarized routing information for remote group of nodes.

IV. Performance Evaluation of AdhocOn Demand Distance Vector (AODV) Routing using Expanded Ring Search (ERS) with Directional Local Repair (DLR) Protocol

AODV is one of the leading reactive protocols and has the advantages of DSR and DSDV protocol. DSDV maintains routes to all destinations with periodical route information flooding and uses sequence numbers to prevent loops. AODV inherits the sequence numbers of DSDV and minimizes the flooding of route information by creating routes on-demand, and improves the routing scalability and efficiency of DSR, which carries the source route in the data packet. In AODV protocol, in order to find a route to the destination, the source broadcasts a route request packet (RREQ). Its neighbors relay the RREQ to their neighbors until the RREQ reaches the destination or an intermediate node that has fresh route information. Then the destination or this intermediate node sends a route reply packet (RREP) to the source node along the path from which the first copy of the RREQ is received. AODV uses sequence numbers to determine whether route information is fresh enough and to ensure that the routes are loop free. In AODV protocol, the route is built on demand and is not updated until the route breaks or times out. The route can’t adapt to topology changes and breaks frequently in the case of high mobility. AODV uses local repair to restrict the route discovery zone so as to reduce overhead. If the source moves away and causes the route to break, it can re-initiate route discovery to the destination. In case an intermediate link breaks and the broken link is near the destination, the upstream node of this broken link may choose to repair the route. It initiates a route request with a fresh destination sequence and the RREQ will be flooded in a zone with a radius no less than the original hop count between this node and the destination. If the upstream node of the broken link decides not to repair the broken route, it will send a route error packet (RERR) upwards to the source node. The source node will re-initiate route discovery in an even bigger zone than that of the local repair if the route is still needed. In AODV Routing protocol using Expanding Ring Search (ERS) the range of flooding of RREQ messages is limited by using a Time to Leave (TTL) parameter. The expanding ring search (ERS) method is used to avoid network wide broadcasting by searching successively
bigger area in the network centered on the source of the broadcast so, it can reduce the total broadcast overhead and end-to-end delay. The lifetime of entire adhoc network can be increased if we can reduce the power consumption by eliminating unnecessary traffic[19]. A new algorithm proposed in [19] is based on clustering of node for link recovery in link failure and also has a directional property of route discovery. It is based on the fact that much energy can be saved if localized route discovery is deployed rather than global flooding during the process of route discovery. Figure 1 shows the utilization of nodes using AODV-ERS protocol. In this figure, Set A (rectangle consisting of all nodes) is the set of nodes to be traversed by the original routing request from the node detecting link failure when one link failure occurs, using ERS. Set B (elliptical area) contains the nodes that must be traversed by route request (RREQ) in order to repair the broken link. Therefore, AODV-ERS protocol utilizes unnecessary nodes when repairing the broken link using ERS, which is shown by (Set A − Set B) in the figure.

In the method proposed in [19], known as Directional Local Repair (DLR) method the flooding of RREQ issued by the node detecting the broken link has a directional property. DLR involves two steps. The first step is the formation of set of candidate nodes. The second step is the repair of broken link.

Step 1: Formation of the cluster of candidate nodes - The candidate nodes cluster refers to the nodes to be traversed by RREQ from the node detecting link failure. The candidate nodes cluster is formed by overhearing the route reply (RREP) messages from the destination. Here we use the idea of overhearing from AODVBR [14]. Its shown in Figure 2, that only the neighbor of a node in the primary path from the source to the destination overhears the RREP message from the destination. (The dashed lines depict overhearing and the solid lines depict the RREP message). Next, each neighbor sets a flag known as candidate flag to indicate whether the node is a candidate node for a future alternative path. In addition to this, each candidate node shares the same number of hops to the destination as the associated member node in the primary path.

In Figure 2, the number of hops from the source node to destination node W is six. When node W sends RREP to node Z, nodes Z’ and Z” overhear the RREP and the number of hops of node W. Next, node Z relays the RREP to node Y enabling Y’ and Y” to overhear the RREP from node Z and the number of hops of node Z. Nodes Z’ and Z” can overhear the RREP and the number of hops of node Z again, but Z’ and Z” already have the number of hops. So they discard the second RREP. Now, we can say Z’ and Z” are associated with node W.

Thus, after the primary path is setup, the cluster of candidate nodes is formed as shown in Figure 3. The cluster of nodes in primary path is shown as dark gray nodes and their neighbours as light gray nodes.
Step 2: Repairing broken Link: From node where link failure occurs, node will broadcast RREQ message to its neighbor nodes. The neighbor on receiving RREQ message checks if candidate FLAG is SET and number of hops of node receiving RREQ is greater than number of hops of the node sending RREQ then the neighbor receiving RREQ message can rebroadcast the RREQ to other neighbor otherwise the RREQ message is discarded. Fig 4 shows the recovery of failure link using candidate nodes.

Comparison of clustering based DLR protocol and AODV-ERS protocol with respect to power consumption and the number of dead nodes is summarized in Table 1. And Table 2.

### Table 1. Power Consumption

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<thead>
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<th>Number of Sources</th>
<th>Power Consumption</th>
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<tr>
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<td>1.01</td>
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<tr>
<td>50</td>
<td>1.02</td>
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### Table 2. Number of Dead Nodes with respect to Simulation Time

<table>
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<tr>
<th>Simulation Time (ms)</th>
<th>Number of Dead Nodes</th>
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</tr>
<tr>
<td>190</td>
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V. CONCLUSION

Routing is an essential component of communication protocols in mobile ad hoc networks. The design of the protocols are driven by specific goals and requirements based on respective assumptions about the network properties or application area. The survey tries to review typical routing protocols and compares two latest routing protocols AODV-ERS and DLR in terms of power consumption and number of dead nodes. The comparison shows considerable reduction in power in the new approach as the number of nodes increases. Also the number of dead nodes is considerably reduced with increase in number of sources.

REFERENCES


