

WIRELESS SENSOR NETWORK: ANALYSIS OF ROUTING PROTOCOLS

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Abstract: The wireless networks have become increasingly popular in the computing industry. This is particularly true within the past decade, which has seen wireless networks being adapted to enable mobility. This article examines routing protocols designed for these ad hoc networks by first describing the operation of each of the protocols and then comparing their various characteristics. The remainder of the article is organized as follows. The next section presents a discussion of two subdivisions of ad hoc routing protocols. Another section discusses current table-driven protocols, while a later section describes those protocols which are classified as on-demand. The article then presents qualitative comparisons of table-driven protocols, followed by demand-driven protocols, and finally a general comparison of table-driven and on-demand protocols.

Keywords: DSR; AODV; CFD; DSDV; ZPR; WRP; MANET, TORA.

I. INTRODUCTION

During the recent past, significant progress in the field of computational fluid dynamics (CFD) has also been made, and CFD is gradually becoming established as an efficient tool in vehicle design. It is recognized that complex flow fields are not easily represented in terms of a closed solution. CFD technology allows for the visualization of complex flow phenomena in a virtual environment that can significantly enhance the learning experience. It has the potential to explore cause-effect relationships through open-ended analyses, and extends analyses beyond what is possible using traditional experimentation, because the end user can easily visualize complex flow phenomena using color contour plots and velocity vector plots. Additional features available to compute many derived parameters along with user-friendly graphical operations allow highlighting the region of interest for detailed analyses.

II. EXISTING AD HOC ROUTING PROTOCOLS

Since the advent of Defense Advanced Research Projects Agency (DARPA) packet radio networks in the early 1970s [1], numerous protocols have been developed for ad hoc mobile networks. Such protocols must deal with the typical limitations of these networks, which include high power consumption, low bandwidth, and high error rates. As shown in Fig. 1, these routing protocols may generally be categorized as:

- Table-driven
- Source-initiated (demand-driven)

dotted lines depict logical descendants. Despite being designed for the same type of underlying network, the characteristics of each of these protocols are quite distinct. The following sections describe the protocols and categorize them according to their characteristics. Table-Driven Routing Protocols Table-driven routing protocols attempt to maintain consistent, up-to-date routing

information from each node to every other node in the network. These protocols require each node to maintain one or more tables to store routing information, and they respond to changes in network topology by propagating updates throughout the network in order to maintain a consistent network view. The areas in which they differ are the number of necessary routing-related tables and the methods by which changes in network structure are broadcast. The following sections discuss some of the existing table-driven adhoc routing protocols. Destination-Sequenced Distance-Vector Routing — The Destination-Sequenced Distance-Vector Routing protocol (DSDV) described in [2] is a table-driven algorithm based on the classical Bellman-Ford routing mechanism [3]. The improvements made to the Bellman-Ford algorithm include freedom from loops in routing tables. Every mobile node in the network maintains a routing table in which all of the possible destinations within the network and the number of hops to each destination are recorded. Each entry is marked with a sequence number assigned by the destination node. The sequence numbers enable the mobile nodes to distinguish stale routes from new ones, thereby avoiding the formation of routing loops. Routing table updates are periodically transmitted throughout the network in order to maintain table consistency. To help alleviate the potentially large amount of network traffic that such updates can generate, route updates can employ two possible types of packets. The first is known as a full dump. This type of packet carries all available routing information and can require multiple network protocol data units (NPDUs). During periods of occasional movement, these packets are transmitted infrequently. Smaller incremental packets are used to relay only that information which has changed since the last full dump [6]. Each of these broadcasts should fit into a standard-size NPDU, thereby decreasing the amount of traffic generated.

The mobile nodes maintain an additional table where they store the data sent in the incremental routing information packets [7].

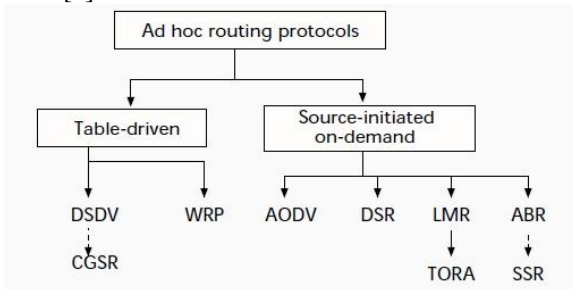


Fig.1 Categorization of ad hoc routing protocols

III. THE WIRELESS ROUTING PROTOCOL

The Wireless Routing Protocol (WRP) described in [4] is a table-based protocol with the goal of maintaining routing information among all nodes in the network. Each node in the network is responsible for maintaining four tables:

- Distance table
- Routing table
- Link-cost table
- Message retransmission list (MRL) table

Each entry of the MRL contains the sequence number of the update message, a retransmission counter, an acknowledgment required flag vector with one entry per neighbour, and a list of updates sent in the update message. The MRL records which updates in an update message need to be retransmitted and which neighbours should acknowledge the retransmission [4].

Mobiles inform each other of link changes through the use of update messages. An update message is sent only between neighbouring nodes and contains a list of updates (the destination, the distance to the destination, and the predecessor of the destination), as well as a list of responses indicating which mobiles should acknowledge (ACK) the update. Mobiles send update messages after processing updates from neighbours or detecting a change in a link to a neighbour. In the event of the loss of a link between two nodes, the nodes send update messages to their neighbours. The neighbours then modify their distance table entries and check for new possible paths through other nodes. Any new paths are relayed back to the original nodes so that they can update their tables accordingly.

IV. ON-DEMAND ROUTING PROTOCOL

Unlike the table-driven routing protocols, on demand routing protocols execute the path-finding process and exchange routing information only when a path is required by a node to communicate with a destination [8].

1. Dynamic Source Routing Protocol (DSR)

Dynamic Source Routing Protocol is Beaconless, Beaconless means there are no hello packet, also there is routing cache. DSR contains two phases, Route Discovery (find a path), Flooding Route Request with TTL from source, Response Route Reply by destination. If an forwarding node has a route to the destination in its route cache, it sends a Route Reply to the source. Route Maintenance (maintain a path) and Route Error.

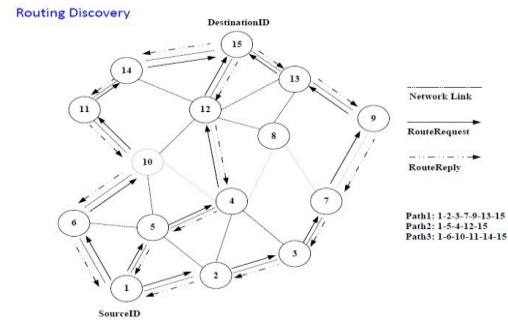


Fig 2: Route Establishment in DSR

Advantage of DSR is that there is no need to updating the routing tables, intermediate nodes are able to utilize the Route Cache, information efficiently to reduce the control overhead, Also There are no "hello" messages needed (beacon-less)

Disadvantage of DSR is that the Route Maintenance protocol does not locally repair broken link. There is always a small time delay at the begin of a new connection.

2. Ad Hoc On-demand Distance-Vector Routing Protocol (AODV)

It is a reactive routing protocol, meaning that it establishes a route to a destination only on demand. In contrast, the most common routing protocols of the Internet are proactive, meaning they find routing paths independently of the usage of the paths. AODV is, as the name indicates, a distance-vector routing protocol. AODV avoids the counting-to-infinity problem of other distance-vector protocols by using sequence numbers on route updates, a technique pioneered by DSDV. AODV is capable of both unicast and multicast routing

Advantage of AODV is that it establish on demand. Destination sequences are used to find the latest path to destination. The connection setup delay is less and Disadvantage of this protocol is that the intermediate node can lead to inconsistent route, Beacon-base, Heavy control overhead.

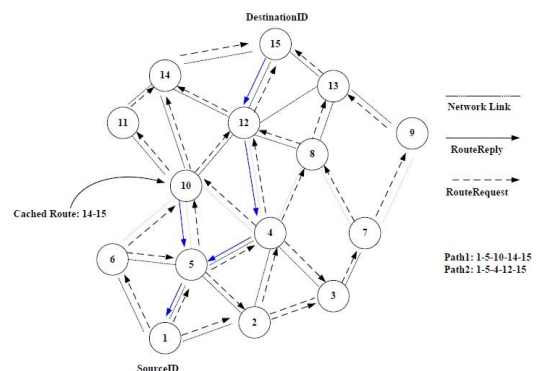


Fig 3: Route Establishment in AODV

3. Temporally Ordered Algorithm (TORA)

The TORA attempts to achieve a high degree of scalability using a "flat", non-hierarchical routing algorithm. In its operation the algorithm attempts to suppress, to the greatest extent possible, the generation of far-reaching control message propagation. In order to achieve this, the

TORA does not use a shortest path solution, an approach which is unusual for routing algorithms of this type. TORA builds and maintains a Directed Acyclic Graph rooted at a destination. No two nodes may 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. Advantage of TORA is that it requires very less control overhead, and disadvantage is that the local reconfiguration of paths results in no optimal routes.

V. TABLE-DRIVEN ROUTING PROTOCOLS

Table-driven routing protocols attempt to maintain consistent, up-to-date routing information from each node to every other node in the network. These protocols require each node to maintain one or more tables to store routing information, and they respond to changes in network topology by propagating updates throughout the network in order to maintain a consistent network view [9]. The areas in which they differ are the number of necessary routing-related tables and the methods by which changes in network structure are broadcast. The following sections discuss some of the existing table-driven ad hoc routing protocols.

1. Destination Sequenced Distance-Vector Routing Protocol (DSDV)

Enhanced from distributed Bellman-Ford algorithm, obtain a table that contains shortest path from this node to every node. Incorporate table updates with increasing sequence number tags, Prevent loops, counter the count-to-infinity problem, Faster convergence. Exchange table between neighbours at regular time interval. There are two types of table updates, first Incremental update takes a single network data packet unit (NDPU) when no significant change in the local topology and second Full dumps update where it takes multiple NDPUs:-When local topology changes significantly or incremental updates require more than a NDPU Table updates are initiated by the destination with the new sequence number which is always greater than the previous one. Single link break cause propagation of table update information to the whole network with odd sequence. The changed node informs neighbours about new shortest path while receiving the table update message with even sequence.

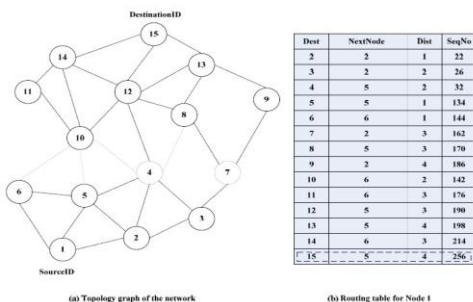


Fig 4: Route Establishment in DSDV

Advantages of DSDV are route setup process is very fast, make the existing wired network protocol apply to ad hoc network with fewer modifications and Disadvantages of DSDV are excessive control overhead during high mobility node, must wait for a table update message initiated by the destination node, cause stale routing information at nodes.

Simulation result for DSDV in [5]

	Low mobility (0.4-0.6 m/sec)	High mobility (3.5-4.5 m/sec)
Delivery ratio of packets (%)	98-100	98-100
End-to-end delay (ms)	6.3-6.6	7.2-7.7
Normalized routing load	0.07 (3 connections/node)	0.24 (3 connections/node)
	0.025 (9 connections/node)	0.07 (9 connections/node)

we can see that the end-to end delay and the routing load increase with the mobility; but the routing load decreases with the number of connections of each node at same mobility.

2. Wireless Routing Protocol (WRP)

Distance table contains distance and predecessor node for a destination Routing table contains shortest distance, predecessor node, successor node, and status of the path. Link cost table contains cost of relaying messages through each link- Number of update periods passed since the last successful update was received (for detecting link breaks). Message retransmission table contains update message that is to be retransmitted with a counter and counter decremented after every update message retransmission

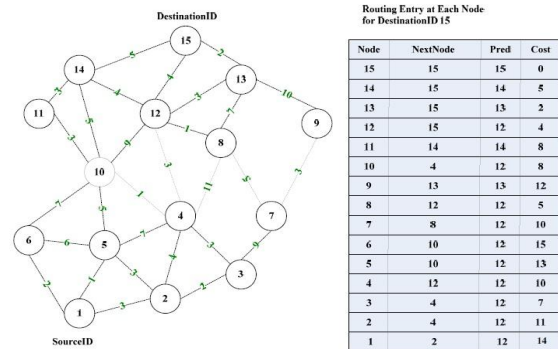


Fig 5: Route Establishment in WRP

Each node implementing WRP keeps a table of routes and distances and link costs. It also maintains a 'message retransmission list' (MRL). Routing table entries contain distance to a destination node, the previous and next nodes along the route, and are tagged to identify the route's state: whether it is a simple path, loop or invalid route. (Storing the previous and successive nodes assists in detecting loops and avoiding the counting-to-infinity problem - a shortcoming of Distance Vector Routing.)

The main advantage is same as DSDV, WRP has faster convergence and fewer table updates and disadvantage of WRP is that it need large memory and greater computing power because of the multiple tables. At high mobility, the control overhead for updating table entries is almost

the same as DSDV, not suitable for highly dynamic and large ad hoc network nodes periodically exchange routing tables with their neighbours via update messages, or whenever the link state table changes. The MRL maintains a list of which neighbours are yet to acknowledge an update message, so they can be retransmitted if necessary. If no change in the routing table, a node is required to transmit a 'hello' message to affirm its connectivity. When an update message is received, a node updates its distance table and reassesses the best route paths. It also carries out a consistency check with its neighbours, to help eliminate loops and speed up convergence.

VI. PERFORMANCE RESULTS OF AODV, DSR, DSDV

The graphs below show the performance of the routing protocol with respect to different metrics considered above. The X-Axis shows the number of nodes and the y-axis shows the Metric considered

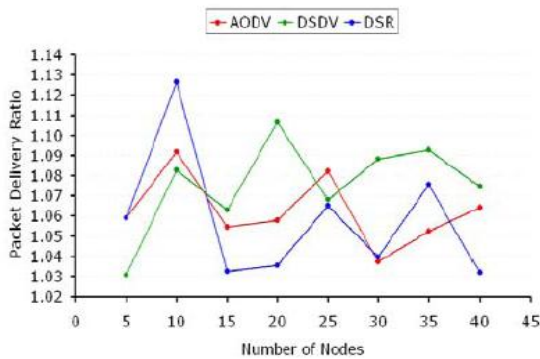


Fig 6: Packet delivery ratio for AODV, DSR, DSDV

In terms of packet delivery ratio (Figure6), DSR performs well when the number of nodes is less as the load will be less. However its performance declines with increased number of nodes due to more traffic in the network [10]. The performance of DSDV is better with more number of nodes than in comparison with the other two protocols. The performance of AODV is consistently uniform.

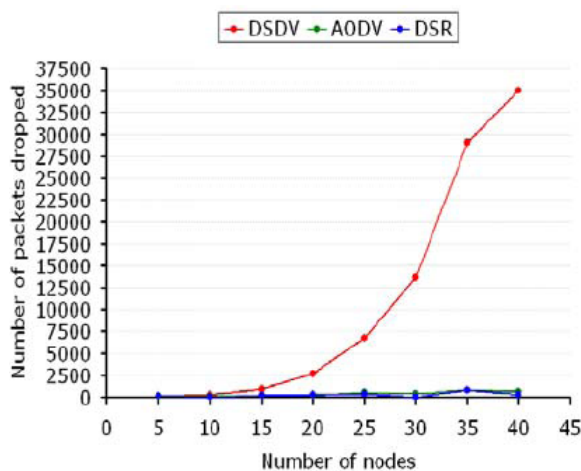


Fig 7: Dropped Packets for AODV, DSR, DSDV

In terms of dropped packets (Figure7), DSDV's performance is the worst. The performance degrades with the increase in the number of nodes.

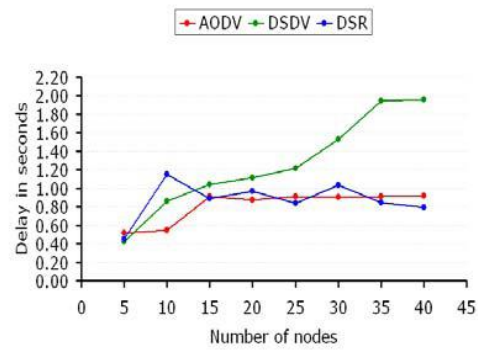


Fig 8: Average End-to-End delay for AODV, DSR, DSDV

For average end-to-end delay (Figure8), the performance of DSR and AODV are almost uniform. However, the performance of DSDV is degrading due to increase in the number of nodes the load of exchange of routing tables becomes high and the frequency of exchange also increases due to the mobility of nodes.

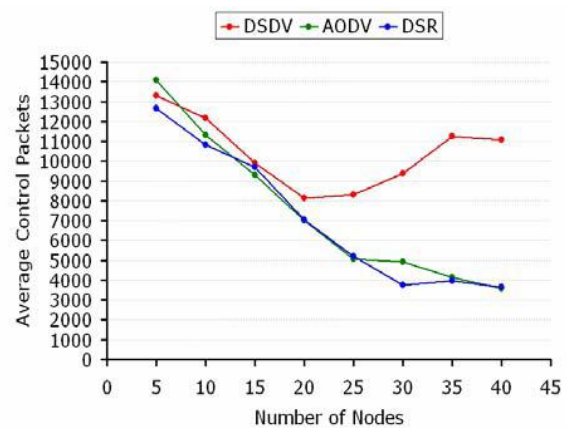


Fig 9: Average Routing Overhead for AODV, DSR, DSDV

In terms of routing overhead (Figure9), the performance of DSR and AODV is almost the consistent. However, that of DSDV is again degrading. The performance of DSDV is almost in line with DSR and AODV till 20 nodes after which the control packet overhead increases well ahead of DSR and AODV.

VII. CONCLUSION

We have presented a comparison of these two categories of routing protocols, highlighting their features, differences, and characteristics. Finally, we have identified possible applications and challenges facing ad hoc mobile wireless networks. While it is not clear that any particular algorithm or class of algorithm is the best for all scenarios, each protocol has definite advantages and disadvantages, and is well suited for certain situations. The field of ad hoc mobile networks is rapidly growing and changing, and while there are still many challenges that need to be met, it is likely that such networks will see widespread use within the next few years.

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