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Performance Comparison of Ad-Hoc VANET Routing Algorithms

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Abstract

We study the problem of multihop routing in vehicular ad hoc networks (VANET). IEEE 802.11p and other vehicular network standards advocate vehicles to issue periodic broadcast messages at regular intervals called beacons. The physical rate adaptation in 802.11 is a deeply investigated, though still open issue. Since 802.11 uses the random access Distributed Coordination Function (DCF) mechanism to access the medium, collisions can occur when two or more stations want to transmit data simultaneously. The challenge of rate adaptation schemes to adapt the physical transmission rate based on channel-related losses, i.e. collisions should not influence the choice of the rate. In this paper we propose a rate adaptation algorithm that behaves like Auto Rate Fallback (ARF), but makes use of the RTS/CTS handshake, when necessary, to decide whether the physical transmission rate should be changed. We evaluate the performance of rate adaptation algorithm, comparing it with other well known algorithms.

Keywords: VANET, Classification, Routing Overhead, Performance Evaluation, Auto-Rate Fallback.

I. INTRODUCTION

Wireless networks can be classified in two types: infrastructured wireless networks and infrastructureless (ad hoc) wireless networks. Ad hoc networks are characterized by the need for efficient routing protocols. According to previous research, the Destination-Sequenced Distance-Vector (DSDV) routing protocol and the Ad Hoc On-Demand Distance Vector (AODV) routing protocol are two good representatives for each routing protocol category, Table-Driven category and On Demand category respectively. We compare via simulation their performance with respect to the pause time of nodes movement.

We find which routing protocol is appropriate for certain network conditions. When the nodes move continually then AODV seems to be better than DSDV. When nodes stay unmoving for a long time then DSDV is preferable.

The second category of vehicular wireless networks is the infrastructureless (not structured) wireless network, also known as wireless mobile ad hoc network – **VANET**. The infrastructureless networks have no fixed router, so all nodes are capable of moving and are dynamically connected in an arbitrary way. Nodes of these networks function as routers themselves discovering and maintaining the paths to other nodes in the network. Such networks are particularly useful in cases where there is not fixed network structure. The nodes of a wireless mobile ad hoc network are equipped with wireless devices for sending and receiving signals and use aerials for broadcasting, multicasting, or a combination of the above. Since their appearance in the '70's, the wireless networks have increasingly become more and more popular.

This became quite noticeable in the course of the previous decade when the wireless networks managed to support the mobility of nodes. There are two categories of mobile wireless networks. The first category is known as infrastructured network and it maintains constant connections with the gates via cables. The access of terminals in these networks is made possible via concrete points of access, which are known as base stations. Wireless local area networks (WLANs) belong to this category.

II. CLASSIFICATION OF AD HOC ROUTING PROTOCOLS

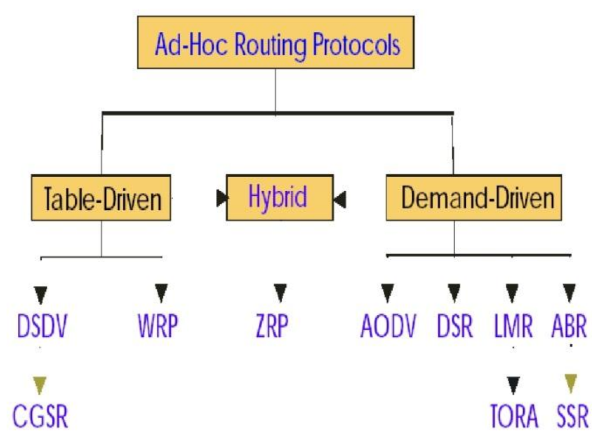

Figure. 1 Classification of Ad hoc Routing Protocols

Table 1 : Ad-Hoc Routing Protocols

Table Driven	Hybrid	Demand Driven	GEOCASTING	Hierarchical	BackPressure Routing	MultiCast Routing
BABEL	HWMP	AODV	MOBICAST	CBRP	LANMAR	MRMP
BATMAN	HRPLS	DSR	AGTSG	CEDAR	**Power Aware Routing Protocols**	EraMobile
HSR	ZRP	LMR	SGTSG	FSR		PUMA
IARP		ABR	IMEP			ARMIS
DSDV		TORA	W2LAN			LAM
WRP		SSR				
LCA		FSDSR				
WAR		DNVR				
CGSR		DMOR				
OLSR		SENCAST				
		ACOR				
		ARIADANE				
		PLBR				
		AORP				

The routing protocols for ad hoc networks have been classified into two categories: table-driven protocols and on-demand protocols. They differ from each other on the way they obtain the routing information. The table driven protocols usually maintain the routing table of the whole network whereas the on-demand protocols only try to keep routes on need to know bases.

The DSDV (Destination -Sequenced Distance-Vector) routing protocol is an algorithm that is based on routing tables and on the classic routing mechanism of Bellman-Ford. We select DSDV algorithm
as the “representative” of the Table-Driven protocols because it maintains a loop-free, fewest-hop (resulting to the creation of fewer forwarded packets) path to every destination in the network. DSDV prevents loops because of the sequence number, which gives the ability to the network to distinguish stale routes from new ones. So this protocol achieves low routing overhead and low packet delay. Routing information is exchanged when significant new information is available, for instance, when the neighbourhood of a node changes[1].

We select AODV algorithm because on the contrary to other On- Demand protocols, it supports unicast and multicast (support multi-party wireless communications) packet transmissions. None of the other On-Demand algorithms incorporate multicast communication. It also appears to achieve the lowest Routing Overhead from all other protocols in its category in accordance with other papers. AODV also contains mechanisms that help to select the least congested route. Its main advantage that counted in our choice is that the overhead of DSR and TORA (temporally Ordered Routing Algorithm) is potentially larger than that of AODV since each DSR and TORA packet must carry full routing information, whereas in AODV packets only the destination address is contained.

III. PREVIOUS WORK

Most previous work on routing protocols for ad hoc networks analyses the performance of only a single algorithm. The performance of the DSDV routing protocol, which is one the most famous routing protocols for multi-hop ad hoc networks, is analysed in its Packet Delivery Fraction (PDF) and Routing Overhead are evaluated. No comparison is made to other routing protocols. ZRP (Zone Routing Protocol) is described and demonstrated in this protocol is suitable for highly versatile networks, characterized by a large range of nodal mobility and large network diameters according to the related paper. AODV-UU differs from others since it is exclusively for Linux. DSDV and AODV appear to be the most appropriate routing algorithms for small networks with few nodes. They achieve high PDF (Packet Delivery Fraction), low Routing Overhead and low Average Delay. They are efficient algorithms because they can easily find routes that approach the optimal routes.

Comparisons among the routing algorithms in ad hoc mobile networks are very difficult to be done because the advantages for one protocol constitute disadvantages for others. considers Packet Delivery Fraction (PDF) and Routing Overhead, as the main performance metrics for DSDV, AODV and DSR without measuring the Average Delay Time. However, they do not suggest the most appropriate routing algorithms for different network conditions. In this paper, we provide an extensive comparison of DSDV and AODV under various network situations[2].

An **ad-hoc routing protocol** is a convention, or standard, that controls how nodes decide which way to route packets between computing devices in a vehicular ad hoc network .

1.	Pro-active (table-driven) routing
2.	Reactive (on-demand) routing
3.	Flow-oriented routing
4.	Hybrid (both pro-active and reactive) routing
5.	Hierarchical routing protocols
6.	Backpressure Routing
7.	Host Specific Routing protocols
8.	Power-aware routing protocols
9.	Multicast routing
10.	Geographical multicast protocols (Geocasting)

Table 2: Main Types Of Classification Of Routing Protocols.

In *ad-hoc networks*, nodes are not familiar with the topology of their networks; instead, they have to discover it.The basic idea is that a new node may announce its presence and should listen for announcements broadcast by its neighbors.Each node learns about nodes nearby and how to reach them, and may announce that it, too, can reach them.

Note that in a wider sense, **ad hoc protocol** can also be used literally, that is, to mean an improvised and often impromptu protocol established for a specific purpose.

The following is a list of some ad hoc network routing protocols.

III. SUPPORTING THEORIES

A **vehicular ad-hoc network** (**VANET**) is a self-configuring infrastructureless network of mobile devices connected by wireless links. Each device in a VANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a VANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger Internet[3].

VANETs are a kind of wireless ad-hoc networks that usually has a routable networking environment on top of a Link Layer ad hoc network.

The growth of laptops and 802.11/Wi-Fi wireless networking have made VANETs a popular research topic since the mid 1990s. Many academic papers evaluate protocols and their abilities, assuming varying degrees of mobility within a bounded space, usually with all nodes within a few hops of each other. Different protocols are then evaluated based on measure such as the packet drop rate, the overhead introduced by the routing protocol, end-to-end packet delays, network throughput etc.

IV. EXPERIMENTS

A. Comparison between AODV and OLSR

As a proactive protocol, OLSR produces large control traffic overhead on the network.This overhead consumes bandwidth. AODV surpasses OLSR in terms of storage and memory overhead because maintaining of the routing tables for the whole network requires much more communication between the nodes as well as much more storage than by using the AODV protocol. Also routes never been used are maintained.

As a reactive protocol the AODV has an evident weakness: its latency. The route discovery process can take some time. This delay can be a crucial factor in a network. Moreover, a proactive part of AODV (route maintenance, HELLO messages) increases the control messages' volume and the transmission cost. It also damages the reactive property of the AODV.

The scalability is another problem of AODV protocol: with growth of the network the average path length increases, and so does the probability that a link becomes invalid. Therefore the AODV is suited only for small and medium size networks, the scalability limit is about 1000 nodes. Simulations of Perkins' group shown that at 1000 nodes AODV performs poorly, only 25% packets are delivered. The number of RREQ messages grows fast linear with nodes population, and at 1000 nodes most packets are control messages.

So the AODV protocol can be used in networks with limited resources: bandwidth, energy, computational power, but with a limited number of nodes, too. AODV is much more adaptable to highly dynamic topologies as OLSR does[4].

B. Comparison between AODV and DSR

The Ad hoc On Demand Distance Vector (AODV) routing algorithm is a routing protocol designed for ad hoc mobile networks. AODV is capable of both unicast and multicast routing. It is an on-demand algorithm, meaning that it builds routes between nodes only as desired by source nodes. It maintains these routes as long as they are needed by the sources. Additionally, AODV forms trees which connect multicast group members.

The trees are composed of the group members and the nodes needed to connect the members. AODV uses sequence numbers to ensure the freshness of routes. AODV decreases maintenance overhead in ad hoc networks, but some path breaks can significantly cause overhead.

Dynamic Source Routing (DSR) is a routing protocol for wireless mesh networks. It is associated to AODV in that it forms a route on-demand when a transmitting computer requests one. However, it uses source routing instead of relying on the routing table at each intermediate device.

Modified Dynamic Source Routing (MDSR) and AODV (RAODV) routing algorithm is the newly proposed algorithm in this paper to reduce the overhead caused by the AODV. Here, applying the link/route stability in MSRAODV for decrease overhead of discovery and maintenance of routing, based on the performance improvement with respect to the Quality of Service, designed for Mobile Ad hoc Network. This routing protocol route request packet didn't change and it is like as AODV, but rout reply packet must be changed for route stability estimation purpose[5].

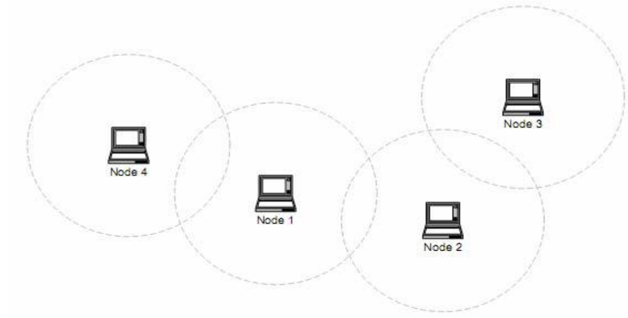

Figure 2: Four nodes on wireless network

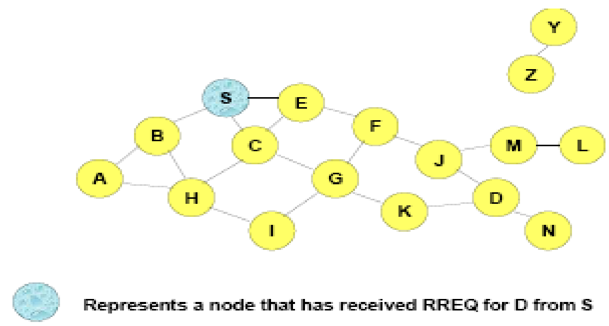

Figure 3: Route Requests in MDSR AODV

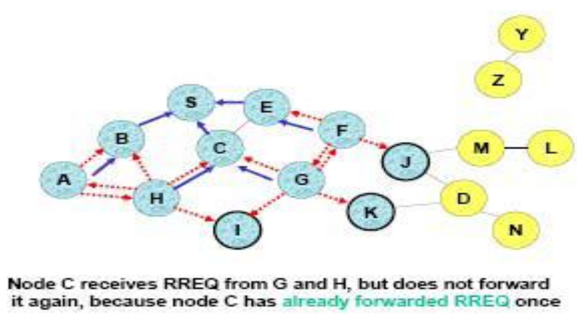

Figure 4: Reverse Path Setup in MDSR AODV

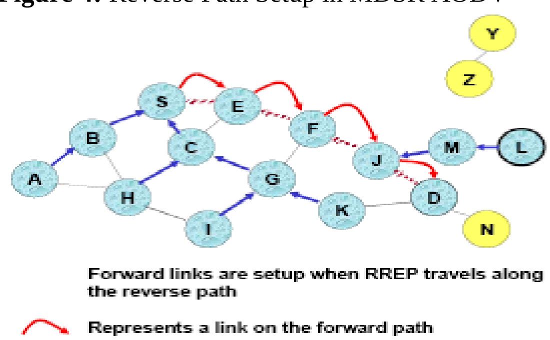

Figure 5: Forward Path Setup in MDSR AODV

V. SIMULATION MODEL AND PERFORMANCE RESULTS

A. Movement and Communication Scenario

Most simulations use a file that describes the movement scenario of nodes. We carefully edit scenario files so that all the different network situations would be extensively simulated. The drawing of a movement scenario file's name is as follows:

scen-LengthxWidth-Nodes-PauseTime-MaxSpeed

where Length and Width are the size of the simulation area, where the mobile nodes are allowed to move to all directions. Nodes are the number of mobile nodes in the simulation, PauseTime is the pause time between successive movements of nodes and it is measured in seconds and MaxSpeed is the maximum speed of the nodes' movement. The change of any of the parameters of the simulations will influence the delivery of packets from a mobile node to a destination node, using routing protocols. All these parameters are supplied in the simulations by movement scenario files. For example, the file scen-670x670-30-20-20, is a movement scenario file with the following parameters: Length = 670m,

Width = 670m, Nodes = 30, PauseTime = 20sec. and MaxSpeed = 20m/sec.

In order to make the treatment of extensive simulations easier, we create a file that describes the communication scenario of a particular simulation. The name of this file is as the following:

cbr-Nodes-Seed-MaxConnection-
TransmissionRate

where Nodes is the number of mobile nodes in simulation, Seed is the accidental number that it produces seed, MaxConnection is the maximum number of connections are realised in simulation time and TransmissionRate is the rate of packets' transmission.

This rate is the number of packets that are transmitted by the mobile nodes (senders) in each second. For example,

File **30cbr-- 1-8-4**, is a communication scenario file with the following parameters: **Nodes** = 30, **Seed** = 1, **MaxConnection** = 8 and **TransmissionRate** = 4.

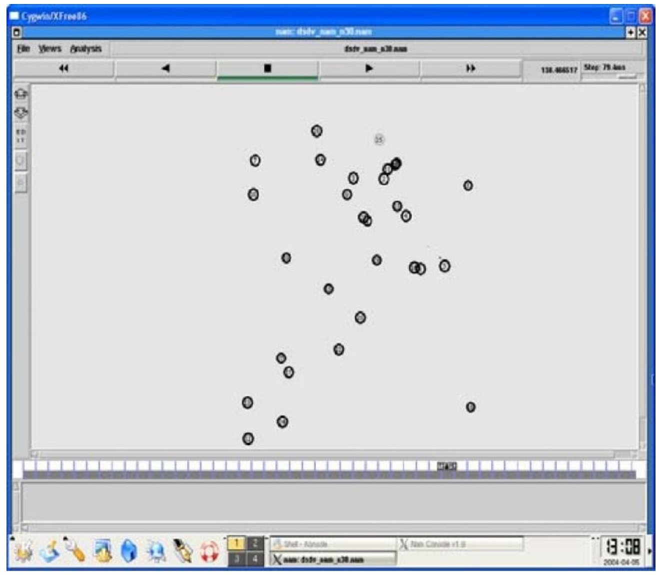

Figure. 6 The Network Animator that shows the above Movement and Communication Scenarios

Below we see in NAM (Network Animator), which is the graphical representation of NS-2 for simulations, an example with a movement and a communication scenario with the following configuration:

Movement scenario: Nodes: 30, pause time: 10.00 sec, max speed: 20.00 m/sec simulation time: 200 sec. max x = 670.00m, max y: 670.00m Communication Scenario : Nodes: 30, max conn: 8, send rate: 4.0, seed: 1

B. Performance metrics

In this paper, we compare via simulation the performance of the DSDV and AODV routing protocols under certain network conditions. We evaluate these routing protocols according to the following performance measurements:

a) **Packet Delivery Fraction (PDF)**: This measurement shows the percentage of successfully delivered packets. The larger this percentage the more efficient the ad hoc routing will be. It is the fraction between the number of packets sent by CBR and TCP sources and the number of received packets by the CBR or TCP sink at destination[6].

b) **Rate of Forwarded/Sent packets (Routing Overhead):** Routing Overhead is actually the percentage of sent packets that are required to reach the destination mobile node. Since a forwarded packet incurs big costs in ad hoc networks, our objective is to minimize the above percentage as much as possible.

c) **Average Delay time:** It is the average delay between the time when a data packet is given to the source node and the time when the packet arrives at the destination node. It is associated with Routing Overhead. Reducing the routing overhead, it naturally would lead to better packet delivery times.

We also used different movement and communication scenarios in order to reach certain useful conclusions. These scenarios include different ways of wireless nodes' movement and different traffic load. The movement scenario files that were created are:

Mobile Networks with 4 mobile nodes, with different pause time of nodes' movement such as 0, 10, 20, 30 and 90 seconds, maximum speed: 20m/sec, topology limit: 670X670 meters and simulation time: 100 seconds. When the pause time is 0 seconds, the nodes move constantly. In contrast, when the pause time is 90 seconds the nodes move a little.

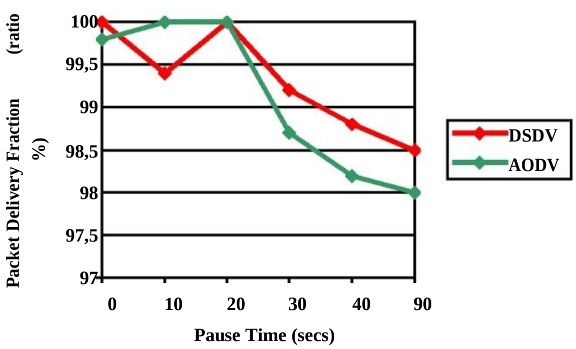

Figure. 7 Packet Delivery Fraction Metric for variable Pause Time

In the above figures, which are the results of our simulations, we can notice the performance metrics of the two routing algorithms when the pause time of nodes' movement is varying. First of all when the pause time is 0 sec, we observe that AODV algorithm causes the creation of more packets than DSDV. On the other hand, AODV achieves smaller average delay than DSDV. Finally, for the Routing Overhead we observe high values with AODV having the lowest. So we prefer AODV for this network because Routing Overhead and Average Delay Time are lower than those of DSDV. When the pause time[7]

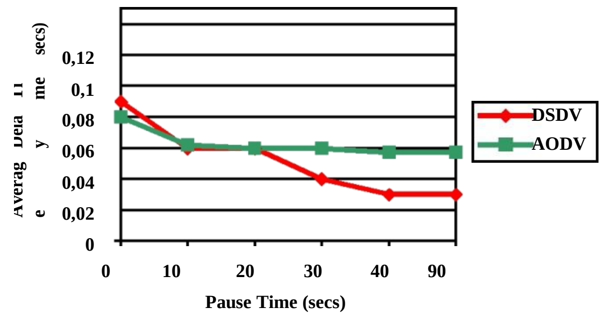

Figure. 8 Average Delay Time for variable Pause Time

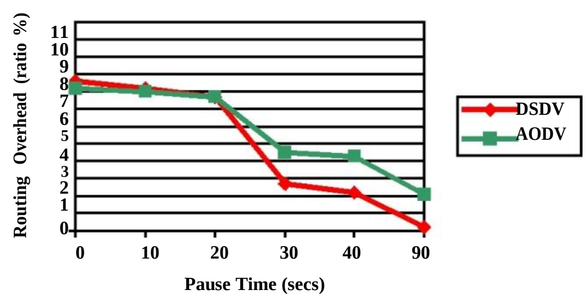

Figure. 9 Routing Overhead Metric for variable Pause Time

increases (10, 20, 30, 40 and 90 secs), we notice that there is an important difference in performance between DSDV and AODV because DSDV produces larger PDF values, lower Routing Overhead and lower Average Delay Time. These metrics make DSDV more appropriate routing protocol than AODV. Finally we observe that there is a great difference in Routing Overhead. This is caused by the creation and the forwarding of many packets (forwarded packets) in order to reach the destination node. So AODV presents higher values of Routing Overhead because it creates forwarded packets and as a result we will possibly have congestion in our network. Deductively, AODV algorithm is a more efficient routing protocol than DSDV, when the pause time of nodes' movement is small. When the nodes stay unmoving for a long time, DSDV is preferable[8].

V. CONCLUSION

Protocol	ARAN[35]	ARIADNE[34]	SAODV[40]	SEAD[37]	SRP[38]
Type	Reactive	Reactive	Reactive	Proactive	Reactive
Encryption Algorithm	Asymmetric	Symmetric	Asymmetric	Symmetric	Symmetric
MANET Protocol	AODV/DSR	DSR	AODV	DSDV	DSR/ZRP
Synchronization	No	Yes	No	Yes	No
Central Trust Authority	Certificate Authority (CA) Required	Key Distribution Center (KDC) Required	CA Required	CA Required	CA Required
Authentication	Yes	Yes	Yes	Yes	Yes
Confidentiality	Yes	No	No	No	No
Integrity	Yes	Yes	Yes	No	Yes
Non Repudiation	Yes	No	Yes	No	no
Arti-Spoofing	Yes	Yes	Yes	No	Yes
Dos Attacks	No	Yes	No	Yes	Yes

Table 3 : Comparison Results

In this paper, we evaluate and compare different combinations of routing algorithms. AODV and DSDV. We selected the DSDV routing as the “representative” of the Table-Driven protocols because it maintains a loop-free fewest-hop, which means the creation of fewer forwarded packets, path to every destination in the network. DSDV achieves a low Routing Overhead and low Average Delay. We selected AODV as the second algorithm for our comparisons because it supports unicast and multicast packet transmissions and it achieves the lowest Routing Overhead from other protocols in its category. AODV also contains mechanisms that help to select the least congested route instead of the shortest route.

While it is not clear that any particular algorithm or class of algorithm is the best for all network conditions, each protocol has definite advantages and disadvantages and has certain situations for which it is well suited. Deductively, AODV algorithm is a more efficient routing protocol than DSDV, when the pause time of nodes’ movement is small. When the nodes stay unmoving for a long time, DSDV is preferable.

The Modified Dynamic Source Routing in Ad hoc On Demand Distance Vector (AODV) routing algorithm is a routing protocol designed for ad hoc vehicular adhoc networks (VANET). MDSR AODV is capable of both unicast and multicast routing and its performance is better with respect to the quality of service comparing DSR and AODV algorithms separately. It is loop-free, self-starting, and scales to large numbers of mobile nodes. DSR AODV may cause overhead. So in order to overcome the overhead process MDSR AODV (RAODV) routing algorithm is found. MDSRAODV is one of the AODV versions which reduces overhead of routing. The Simulation Output shows that Node 1’s Neighbors receive the RREQ message they have two choices; if they know a route to the destination or if they are the destination they can send a Route Reply (RREP) message back to Node 1, otherwise they will rebroadcast the RREQ to their set of Neighbors.

In this paper the AODV routing protocol has been reviewed. As a reactive protocol AODV transmits network information only on-demand. The limited proactive part is the route maintenance (HELLO messages). The AODV protocol is loop-free and avoids the counting to infinity problem by the use of sequence numbers. This protocol offers quick adoptation to mobile networks with low processing and low bandwidth utilization. The weaknesses of AODV include its latency and scalability. The main conclusion of this paper is that the choice of which protocol to use depends on the properties of the network.

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