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Comparing AODV and CAODV Routing Protocols

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Abstract

Wireless Sensor Networks (WSNs) consist of large number of sensing nodes that organize themselves into multi-hop wireless networks. It is desirable for communication protocols to minimize the communication overhead and hence the energy consumption while keeping the data delivery relatively reliable. An ad hoc wireless network consists of mobile networks which creates an underlying architecture for communication without the help of traditional fixed-position routers. However, the architecture must maintain communication routes although the hosts are mobile and they have limited transmission range. There are different protocols for handling the routing in the mobile environment. So, in this paper we present two protocols –one is CAODV(Cross-Layer AODV),based on a cross-layer design and Ad hoc On-Demand Distance Vector (AODV) routing protocol used in wireless sensor networks -and the other is AODV(Ad hoc On-Demand Distance Vector) routing protocol used in ad hoc wireless networks and the comparison of these protocols

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1 Introduction

As wireless communication technology is increasing daily, with such growth it would not be practical or physically possible to have a fixed architecture for ad hoc wireless network and wireless sensor network. The Ad hoc On-Demand Distance Vector(AODV) protocol works well in MANETs but as the density of nodes in WSN is very high so using AODV can lead to high overhead of protocol packets and high probability of collisions when broadcasting RREQs.

So a new protocol to address the above problems in WSNs is designed called Cross-Layer AODV(CAODV).CAODV adopts two mechanisms: Delaying Transmission(DT) and Efficient Broadcasting(EB).The DT reduces the probability of collisions while EB reduces the overhead.

This paper will compare the two routing protocols: Ad hoc On-Demand Distance Vector (AODV) protocol and Cross-Layer AODV(CAODV) protocol. The remaining part of this paper is organized as follows. Sec 2 will consist of information about AODV protocol and Sec 3 will consist of information about CAODV protocol with their respective advantages and disadvantages at the end of the sections. Sec 4 will give the actual comparison of AODV and CAODV. Sec 5 will be the conclusion of this paper.

2 Ad hoc On Demand Distance Vector (AODV)

2.1 Introduction to AODV

AODV is a reactive protocol which means that the routes are created and maintained only when they are needed. In the AODV, a routing table is used to store the information about the next hop to the destination and a sequence number which is received from the destination and indicates the freshness of the received information.

The messages in AODV are transmitted by using IP limited broadcast address, but the messages are checked for the contents so that they will not be broadcasted throughout the entire network. Some of the messages like route request message(RRQ) are supposed to be spread widely in the network.

2.2 Routing

2.2.1 Sequence numbers

The sequence numbers are used for removing the old and invaluable information from the network.

The host also has its own sequence number, which must be incremented in two different cases: before it sends RREQ message and when the host sends an RREP message responding to the RREQ message.

2.2.2 RREQ, RREP and RREP-ACK messages

The route request message (RREQ) is sent when the host is unaware of the route to the needed destination host or the existing route has expired. The RREQ message contains the destination sequence number which is the last known sequence number of the destination host entry found in the routing table.

When the host receives RREQ message, it checks the time period between the last RREQ messages from the same host and will discard the message if it is under some specified limit. Next the host increases the hop count by one in the RREQ message and updates its own routing table based on the sequence number and the requested host's address.

When the host receives an RREP message it will search for the previos hop and will increase the hop metric by one. If there is no routing entry for the previos hop, then the route will be created but without any valid sequence number.

2.2.3 RERR messages, route expiry and route deletion

When a link breakage happens the host must invalidate the existing route in the routing table entry.

If the host detects a link breakage of the active route, then the host makes a list of unreachable destinations based on the routing table entries where the unreachable neihbour will act as the next hop address.

2.2.4 Repairing

The host can try to locally repair a link when a link breakage occurs if the destination is no further than some specified amount of hops. To repair a link the host increases the destination sequence number and will broadcast the RREQ message to the host.

2.2.5 Hello messages

However AODV is a reactive protocol still it uses the Hello message at given periods to inform its neighbours that a link to the host is alive. The Hello messages are broadcasted with TTL value equal to 1, so that the message cannot be forwarded further.

2.2.6 Routing table structure

This is the actual data structure where all needed information about the routes is being stored. The routing table must contain at least the following fields: destination address, destination sequence number, hop count, next hop, lifetime, precursor list, and the route state.

2.3 Advantages

- As the AODV protocol is a flat routing protocol so it does not need any central administrative system to handle the routing process.
- AODV tries to keep the overhead of the messages small in Ad hoc wireless networks.
- The AODV protocol is loop free and avoids the counting to infinity problem by the use of the sequence numbers.

2.4 Disadvantages

- A big number of routes can break resulting repeated route discoveries and error reports in the network.
- AODV cannot be efficiently used in wireless sensor networks because as density of nodes is very high in wireless sensor networks so it can cause high overhead and high probability of collisions when broadcasting RREQs.
- The search latency affects the AODV protocol as the AODV protocol needs to discover the route first in order to send the actual data.

3 Cross-Layer Ad hoc On Demand Distance Vector (CAODV)

3.1 Introduction to CAODV

In CAODV, there are two mechanisms used to overcome the problems of overhead and high probability of collisions offered by AODV protocol. These two mechanisms are: Delaying Transmission (DT) for reducing the probability of collisions and Efficient Broadcasting(EB) for minimizing the overhead of flooding.

3.2 Network Topology

The three main topology structures used in WSNs are: star topology, mesh topology, and star-mesh topology.

A WSN with a star topology is a single-hop network in which an ordinary node would directly communicate with a “base station” and not with another ordinary node. In this paper, we focus on the WSNs with the mesh and star-mesh topologies in which routing protocols are needed.

3.3 Architecture and Strategy of CAODV

The purpose of using cross-layer designs with AODV is to exploit the dependence between protocol layers to obtain performance gains.

Fig. 1 and Fig. 2 show the architecture of CAODV and the strategy respectively. In Fig. 1, the mechanisms of Delaying Transmission (DT) and Efficient Broadcasting (EB) are implemented in the network layer, while utilizing the information provided by the module of Distance Estimation (DE) and the one-hop neighbor state table located in the MAC layer.

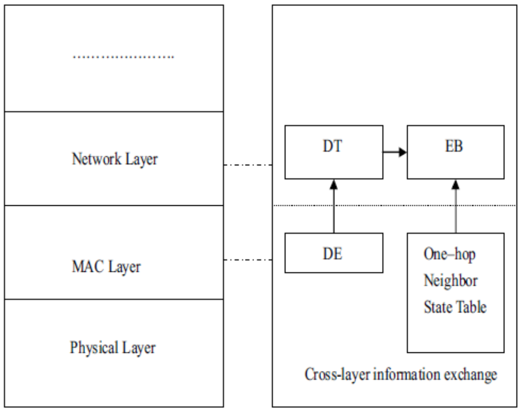

Figure 1. Architecture of CAODV

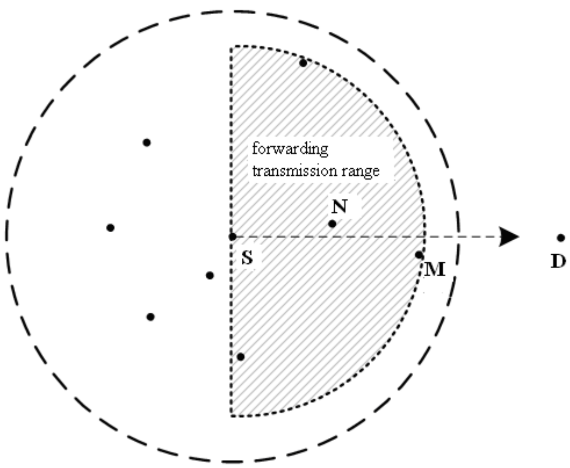

Figure 2. Strategy of CAODV

Fig. 2 shows the strategy of CAODV: let S be the source node that broadcasts a RREQ for D which is the Destination node. M and N are located in the forwarding transmission range (the shadow area) of S and the Distance between M and S is greater than that between N and S. According to CAODV, if M has already rebroadcasted the RREQ received from S, N should try its best to prevent the rebroadcast of this RREQ by itself.CAODV has two basic rules for the dissemination process of RREQs in order to realize this strategy: (a) the nodes that are further from the previous hop should rebroadcast the RREQ (received from the previous hop) earlier implemented by DT; (b) if all of a node's neighbours have received a RREQ, the node should simply discard this RREQ and not rebroadcast it (implemented by EB).

3.4 Delaying Transmission (DT)

This mechanism is used to reduce the probability of collisions when broadcasting RREQs as well as make way for Efficient Broadcasting (EB). Due to the high density of nodes in WSNs, a node has many one-hop neighbors which might receive a RREQ almost simultaneously when the node broadcasts one. Then these neighbors may rebroadcast the RREQ almost at the same time. This would lead to high probability of collisions and retransmissions. The Broadcast Back-off time (TBBo) for the nodes further from the previous hop should be longer than that for those nodes which are nearer to the previous hop. So our first problem is to estimate the distance between two nodes. DT makes use of the distance information provided by the module of DE(Distance Estimation) located in the MAC layer.

3.4.1 The module of Distance Estimation (DE)

There are normally two kinds of methods used for distance estimation: the methods based on GPS and the methods based on signal power. The GPS methods cost too much, especially when there are large number of nodes in a WSN. So, the module of DE uses the method based on signal power.

$$P_{received} = KP_{max} / (d^n).$$

where P_{max} is assumed to be the maximum power of a node's transmitter. $P_{received}$ is the power of received signal and d is the distance between transmitter and receiver. K is a constant and n is the exponent decided by the environment.

$$d = \sqrt[n]{KP_{max} / P_{received}} = K_1 \sqrt[n]{P_{max} / P_{received}}.$$

Where $K_1 = \sqrt[n]{K}$.

3.4.2 Broadcast Back-Off Time(T_{bbo})

$$T_{BBO} = T_{max} \frac{R_{max} - d}{R_{max}}.$$

where T_{max} and R_{max} are the maximum Broadcast Back-off time and the maximum transmission range of a node respectively.

But this method to calculate T_{bbo} cannot be applied to the WSNs in which the nodes have relatively high mobility because this will always select the nodes that are the furthest to its previous hop to transmit RREQs first and so the routing protocol will tend to select the routes with the weakest links which can be easily disconnected due to the mobility of nodes. So, we can modify equation (3), in order to enhance the stability of links, as follows:

$$T'_{BBO} = T_{max} \frac{|d_0 - d|}{R_{max}}.$$

d_o is related to mobility of nodes in WSNs and in CAODV, a low mobility situation in which d_0=0.8 R_{max} , is considered.

In CAODV, T_{BBO} is calculated only when a node receives a new RREQ for the first time. When the node receives a RREQ which has been received before, T_{BBO} is not recalculated.

3.5 Efficient Broadcasting (EB)

This mechanism is used to minimize the redundancy of overheads. In this mechanism we use a new packet called Hello Neighbor (HN) to exchange neighbor information between one-hop neighbors so that the nodes can construct two-hop neighbor tables.

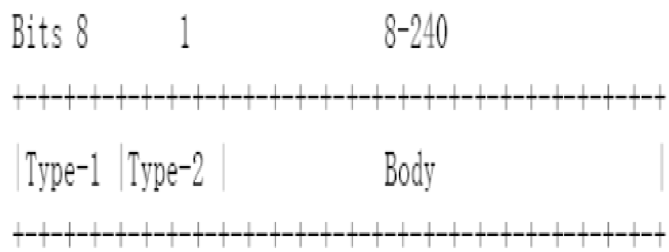

Figure 3. Format of hello neighbor packet

The Hello packet will carry the IDs of newly increased or decreased neighbors in order to minimize the overhead.

- Type 1 in the packet will identify that this is an HN packet. In CAODV protocol, this type is specified upto 6.
- Type 2 is a one-bit field which will differentiate whether this packet carries the increased or decreased neighbors. In CAODV, 0 represents the IDs of increased neighbors while 1 represents those of newly decreased neighbors.
- The length of Body field is variable in the range of 8 to 240 bits and whenever an HN carries information more than 30 neighbors, the packet will be fragmented.

3.6 Advantages

- CAODV can be used efficiently in wireless sensor networks because it can cause less overhead.
- Another advantage is it will cause less possibility of collisions in wireless sensor networks as the density of nodes is very high in these types of networks.
- As compared to AODV, CAODV provides more accurate local topology information to nodes.

3.7 Disadvantages

- As the cross layer design leads to several adaptation loops so the complex interaction of these loops may endanger the stability of the system.
- The cross-layer AODV has to compromise between the performance and longevity of any system.
- The cost of development of CAODV protocol is very high.

4 Comparisons of the Protocols

4.1 Performance and Scalability

In a network with light traffic and low mobility the AODV protocol scales perfectly to the larger networks with low bandwidth and storage overhead. But for large traffic and high mobility of nodes in wireless sensor networks, the AODV protocol performs very poor.

On the other hand, the CAODV protocol performs better as compared to the AODV protocol even when the density of the nodes increases in the wireless sensor networks. The performance is increased in CAODV protocols as these protocols can reduce high overhead and high probability of collisions in the wireless sensor networks and the networks with high density of nodes.

So from the above information, the CAODV protocol performs better in the systems with high density of nodes as compared to the AODV protocol. But when it comes to maintaining the performance and longevity of the systems, the CAODV protocol has to compromise between one of them.

4.2 Resource Usage

In the AODV protocol, though the Hello Messages are sent periodically but it is limited and the size of the control message is small. So the AODV protocol uses less number of resources.

In the CAODV protocol, the usage of resources is the same as that of the AODV protocol but as the cross layer design leads to several loops so the complex interaction of these loops may endanger the stability of the systems.

So from the above information, the usage of resources is less in both the AODV and CAODV protocols. But because the core architectures of the protocols are completely different, the resource usage mostly depends on the network suitability of the protocols.

4.3 Security

The AODV protocol needs less protection of the control messages as it is enough to protect the RREP and RRER messages in order for the protocol to be secured. But there are some security factors whose security cannot be provided by the AODV protocols like flooding is the most severe security threat in multi-hop networks which cannot be secured by the AODV protocol.

The CAODV protocol when it comes to security is more secure than the AODV protocols as the security threat like flooding in multi-hop wireless networks can be secured by the CAODV protocol.

So from the above information, the CAODV protocol is more secure than the AODV protocol. The CAODV protocol provides security mechanisms for flooding attacks, if any, in the systems while the AODV protocol is unable to provide such security mechanisms for flooding attacks.

The Table1 below shows the comparison of the CAODV protocol and the AODV protocol.

Table1. Comparison of CAODV and AODV protocols

	Cross-Layer CAODV	AODV
Performance	Better in systems with high density of nodes	Poor in systems with high density of nodes
Cost of development	Very high	less
Scalability	Less scalable as density of nodes increases	Highly scalable as density of nodes is less
Resource Usage	Less no. of resources used	Less no. of resources used
Security	Very high	High
Probe Flood Detection	Yes	No
De authentication Flood Detection	Yes	No
Hello Flood Detection	Yes	No

5. Conclusion and Future Work

In this paper a brief introduction of AODV and CAODV protocols is given along with their respective advantages and disadvantages at the end of these sections.

The comparison of the AODV and CAODV protocols is done according to their advantages and disadvantages.

In the comparison it is found that CAODV performs better when it comes to wireless sensor networks with high density of nodes as compared to AODV protocol.

But there are some disadvantages of CAODV protocol which can be used as an implementation for future work in the cross layer design problems field in wireless sensor networks.

Another future work possibility can be for very high density of nodes, the nodes with similar characteristics can be put into one cluster using some clustering techniques to reduce several adaptation loops and cost of development.

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