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Using the Smart-AODV Protocol, MANET Routing Overhead is Reduced

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Abstract: Many ad-hoc routing methods use broadcasting, a popular transmission technique, to address a variety of problems, including locating a route to a certain location.When broadcasting packets frequently generate contention and conflicts in transmission among close-by nodes, the problem of broadcast storm is created. The ad hoc on-demand distance vector routing protocol uses the straightforward technique of flooding to implement broadcast communications. Flooding, however, loses its effectiveness due to redundant transmissions and multiple access interferences. In the beginning, this paper examines the well-known ad hoc on-demand distance vector routing technique (AODV). Then, in order to decrease the routing overhead, the ineffective flooding approach used in its route discovery process is modified. The Smart-AODV suggested protocol was described. This routing method is made to prevent broadcasts of the same route requests for the same destination from happening repeatedly. The simulation results show that Smart-AODV can outperform the AODV protocol by significantly reducing the overhead traffic during the route discovery phase.

Keywords: *Mobile ad-hoc networks, ns-2, routing overhead, broadcasting, flooding, and ad hoc on-demand distance vector.*

1. Introduction

Mobile Ad Hoc Networks (MANETs) have gained significant attention in recent years due to their self-configuring nature and ability to operate without fixed infrastructure. However, the dynamic topology and resource constraints of MANETs pose unique challenges for routing protocols. The Ad hoc On-Demand Distance Vector (AODV) routing protocol has been widely used in MANETs, but it suffers from high routing overhead, especially in large or highly mobile networks.

This paper introduces Smart-AODV, an enhanced version of AODV designed to address the routing overhead issue. We explore the key features of Smart-AODV and evaluate its performance in comparison to traditional AODV. Our focus is on demonstrating how Smart-AODV reduces routing overhead while maintaining or improving other essential network performance metrics.

A network that doesn't have any infrastructure and is made up of dynamically moving nodes is known as a mobile ad hoc network (MANET). Each node has a wireless transmitter, as well as a receiver and antenna[1]. These nodes serve as a router and are wirelessly connected to one another. Nodes can move around freely and arrange themselves however they see fit in mobile ad hoc networks. These characteristics make MANET highly useful in locations where the present infrastructure is unable to support communication, such as earthquake or disaster zones [2].

There are two types of routing protocols for mobile ad hoc networks: proactive routing protocols and reactive routing strategies. While proactive routing methods like OLSR [3] and FSR [4] routinely update the routing table, reactive routing techniques like AODV [5] and DSR [6] do not.Instead, they start the route discovery process through flooding [7] when there is data to send, which is the primary cause of routing overhead. Reactive routing protocols operate better in highly dynamic networks while proactive routing protocols are excellent for networks with minimal mobility.

The reactive protocol's main task is to find a path from a source node to a destination. AODV on-demand routing protocols, which only perform route discovery when a packet needs to be routed to a destination when there isn't one already in place, are the subject of this study. In prior work, the scalability and resilience of AODV have been shown [8]. It is moreover one of the earliest ad hoc network protocols to be standardized [5]. The route request, which often floods the whole network, is the most expensive activity in AODV in terms of overhead. As a result, techniques that reduce the amount of route searching are useful for improving performance.

In wireless ad hoc networks, lowering the overhead associated with route discovery is crucial. A number of nodes attempting to interact simultaneously over the same wireless channel are known as a "broadcast storm"

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[9], which is caused by broadcasting route request messages throughout the network. As a result, there is competition for the medium, congestion, packet loss for control packets, delays for the packets that get through, and a general decline in network performance. In addition to saving bandwidth, limiting the number of route requests also lessens the impact of broadcast storms, which lowers network overhead,for additional information see[11].

We provide a smart-AODV technique in this work and assess its potential for lowering the route discovery overhead. For the duration of the path discovery process, the node will store the route request ID and source IP address in a buffer in line with the advised protocol. Additionally, In order to avoid sending several route requests to the same location, the destination IP address is buffered. This could reduce the requirement for inundated route requests when communication is necessary for these locations. We simulate and demonstrate how the findings reduce routing overhead using the NS-2 simulator [10].

This essay's remaining sections are organized as follows. Research that is pertinent to the topic at hand is presented in Section II. Section III talks about the suggested protocol (smart-AODV). Section IV presents the simulation and outcome analysis. Section V presents a summary and future works.

2. Related Work

To address these issues, AODV has undergone a number of improvements. Several of these AODV innovations that aimed to reduce routing overhead were summarized in this section. It can be calculated by dividing the total number of delivered data packets by the total number of routing packets.

An on-demand node disjoint multipath routing protocol is suggested by [10] as a solution to the problems with AODV routing systems. The protocol has features like increased packet delivery rate and reduced routing overhead.

2.1. Mobile Ad Hoc Networks (MANETs)

MANETs are self-configuring networks of mobile devices connected wirelessly without a fixed infrastructure. Each device in a MANET can move independently, resulting in frequent and unpredictable topology changes. This dynamic nature presents unique challenges for routing protocols, as they must adapt quickly to maintain network connectivity and efficiency.

2.2. Ad hoc On-Demand Distance Vector (AODV) Routing Protocol

AODV is a reactive routing protocol designed for MANETs. It establishes routes on-demand, meaning that a route is only created when a node needs to communicate with another node for which it has no route information. AODV uses route request (RREQ) and route reply (RREP) messages for route discovery, and route error (RERR) messages for route maintenance. While AODV is effective in many scenarios, it can generate significant routing overhead, particularly in large or highly mobile networks.

2.3. Smart-AODV Protocol

Smart-AODV is an enhanced version of the AODV protocol designed to reduce routing overhead in MANETs. It incorporates intelligent mechanisms to optimize route discovery and maintenance processes, resulting in more efficient network operation. Smart-AODV introduces several key features to improve upon traditional AODV: Adaptive Hello Interval: Dynamically adjusts the frequency of Hello messages based on network stability.

Intelligent Route Caching: Implements an improved caching mechanism to reduce redundant route discoveries. Selective Flooding: Limits the propagation of RREQ messages based on network conditions and historical data. Link Quality Assessment: Incorporates link quality metrics in route selection to improve stability.

2.4. Improvements over Traditional AODV

Smart-AODV addresses several limitations of traditional AODV:

Reduced flooding: By using selective flooding, Smart-AODV decreases the number of control messages propagated through the network.

Improved route stability: The link quality assessment feature helps in selecting more stable routes, reducing the frequency of route breaks.

Lower control overhead: Adaptive Hello intervals and intelligent route caching contribute to a significant reduction in control message overhead. The AODV-I protocol, an upgraded version of the AODV protocol, was put forth in [12]. By incorporating congestion processing and routing repair methods in the route request message, the proposed protocol reduces the packet loss rate and enhances network usage.

An improved AODV routing protocol was put forth in [13]. The transmission overhead is reduced by preventing needless broadcasting of route request messages and pointless traversal of route reply messages.A modified version of the AODV protocol was put forth in [14] to lessen routing overhead. A reply model method was designed to carry out that. The NS-2 simulator was used to assess the routing protocol's performance at various mobility rates, and it was discovered that the proposed routing protocol has less routing overhead than AODV.

An estimated distance-based routing system was put forth in [15] as a generic modification to route discovery. This protocol can reduce routing overhead, limit the propagation range of a route request message, and enhance routing performance in dense networks with high mobility. According to [16], the multi-hop routing protocol only provides tolerably excellent performance at specific transmission power levels, and using high transmission power will result in less overheads and improved performance.

In order to reduce network overhead, a probabilistic rebroadcast method is utilized in [17]. In order to accurately calculate the increased coverage ratio and rebroadcast order, a rebroadcast delay is used to discover the neighbor's coverage information.

All of the above research make various attempts to lower the AODV protocol's routing overhead. None of them think it significantly reduces routing costs to prevent several route requests intended for the same destination from being broadcast at the same time.

3. The Proposed Protocol (Smart-AODV)

In AODV, a source node searches its routing table for a path that is open to that destination whenever it wants to begin communication with another node. If the source is unable to find a path, it broadcasts a route request message over the whole network. This route request message and a route reply message are returned by the destination or a node that has a route to the destination. The source can begin transmitting data packets along the route that the route reply message originated from once it has received the route reply message. Nodes that get route reply messages from intermediate nodes update their routing databases with entries for the source, while nodes that receive message for the destination do the opposite. The next hop to the relevant node is contained in the routing table item.

As a result, A path is created. between a source and a destination, hop-by-hop along the route reply message's course; the entire route need not be included in each data packet [5] contains additional details about AODV. The figure 1 shows the flowchart of Smart-AODV protocol.

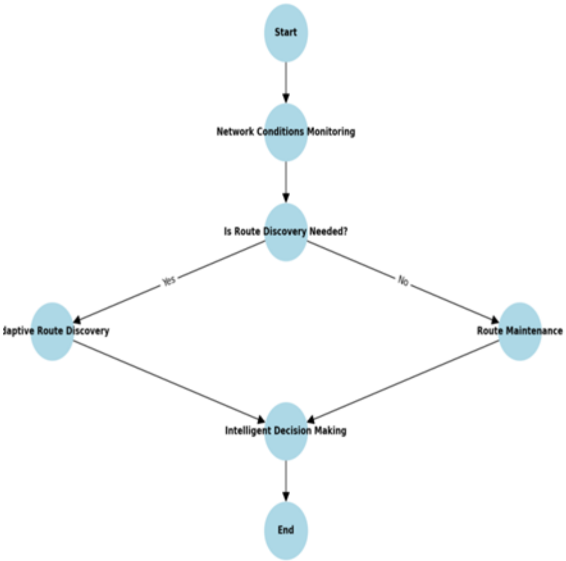

Fig. 1. The Smart-AODV protocol

The figure depicted steps of the Smart-AODV protocol as follows:

1. **Start**
2. **Network Conditions Monitoring: Continuously monitor network conditions.**
3. **Is Route Discovery Needed?**
   - **If Yes, proceed to Adaptive Route Discovery.**
   - **If No, proceed to Route Maintenance.**
4. **Adaptive Route Discovery: Perform adaptive route discovery based on current network conditions.**
5. **Route Maintenance: Optimize route maintenance processes.**
6. **Intelligent Decision Making: Use intelligent algorithms to decide when to initiate route discovery or maintenance.**
7. **End**

The flowchart visually represents the steps involved in the Smart-AODV protocol, emphasizing the adaptive and intelligent mechanisms that help reduce routing overhead in MANETs. In dense mobile ad hoc networks, the quantity of control packets is increasing, which causes a large increase in routing overhead. For the duration of path discovery, the node buffers the route request ID and source IP address before broadcasting the route request packet. This strategy can help reduce the routing overhead.

Additionally, In order to avoid sending several route requests to the same location, the destination IP address is buffered. With this method, a node will pause processing if a new route request it gets has the same destination as one that is already being processed.

The node that suspended the request will send another route reply to the paused request when it receives a route reply for the earlier request. Through the removal of some route request messages that are targeted to the same destination, this technique lowers the overhead involved with route finding.

Any decrease in route request messages is anticipated to enhance performance greatly. After all, they are the primary cause of control overhead because they overwhelm the whole network. The network is unaffected if some route request messages headed in the same direction are suspended. This is due to the fact that in a dense network with many of connections, neighbors nodes will still bombard other nodes with packets that a node does not forward. As a result, our technique results in less control traffic since there is less flooding.

3.1. Code Sample and Procedures for Smart-AODV

- The current aodv.cc and aodv.h files have been modified.
- The destination address is added to the broadcastID class in aodv.h as follows:
  - BroadcastID(nsaddr_ti, u_int32_t b,nsaddr_t j) { src = i; id = b;dst=j
  - In aodv.cc, we changboth id_insert and id_lookup functions. Here is a sample of the code:

```
void
AODV::id_insert(nsaddr_t id, u_int32_t bid,nsaddr_t s_id) {//modefied
BroadcastID *b = new BroadcastID(id, bid,s_id);

 assert(b);
 b->expire = CURRENT_TIME + BCAST_ID_SAVE;
 LIST_INSERT_HEAD(&bihead, b, link);
}

/* SRD */
bool
AODV::id_lookup(nsaddr_t id, u_int32_t bid, nsaddr_t s_id) {//modefied
BroadcastID *b = bihead.lh_first;

 // Search the list for a match of source and bid
 for( ; b; b = b->link.le_next) {
   if( ((b->src == id) && (b->id == bid))  || (b->dst == s_id))
     return true;
 }
 return false;
}
```

4. Simulation and Result Analysis

Using the NS-2 simulator, we ran simulations for both AODV and smart-AODV in order to assess the suggested protocol (smart-AODV).The platform for the simulation is NS-2 [18]. A discrete event simulator called NS-2 was created by Berkeley University researchers with networking research in mind. TCP, routing, and multicast protocols can all be simulated using NS-2 over wired and wireless networks. The performance analysis was completed using the AWK script [19]. We have used the following simulation environment for our simulation:

Table 1. Simulation Environment

Parameter	**Values**
Simulator	NS2(Version 2.35)
Channel Type	Channel/Wireless Channel
Radio-propagation model	Propagation/TwoRayGround
Network Interface Type	Phy/WirelessPhy
MAC Type	Mac/802.11
Interface Queue Type	Queue/DropTail/ PriQueue
Link Layer Type	LL
Antenna Model	Antenna/OmniAntenna
Maximum packet in ifq	50
Area(M*M)	500
Source Type	CBR
Routing Protocol	DSDV and AODV

Here are the mathematical equations relevant to the performance metrics and operations of the Smart-AODV protocol:

4.1. Routing Overhead

Routing overhead refers to the total number of control messages (RREQ, RREP, RERR) generated during the route discovery and maintenance processes.

Routing Overhead= $\sum_{i=1}^{N}$((RREQi+RREPi+RERRi)) (1)

Routing Overhead= where N is the number of nodes, RREQ is the number of Route Request messages, RREP is the number of Route Reply messages, and RERR is the number of Route Error messages generated by node i.

4.2. Packet Delivery Ratio (PDR)

The packet delivery ratio is the ratio of the number of packets successfully delivered to the destination to the number of packets sent by the source.

PDR=$\sum_{i=1}^{N}$(Packets Deliveredi/ $\sum_{i=1}^{N}$(Packets Senti)) (2)

Where N is the number of nodes, Packets Deliveredi is the number of packets successfully delivered by node i, and Packets Senti is the number of packets sent by node i.

4.3. End-to-End Delay

End-to-end delay is the average time taken for a data packet to travel from the source to the destination.

End-to-End Delay=$\sum_{i=1}^{M}$((Time Receivedi−Time Senti)) (3)

Where M is the total number of packets received, Time Receivedi is the time when packet i is received, and Time Senti is the time when packet i is sent.

4.4. Adaptive Route Discovery

Adaptive route discovery adjusts the route discovery frequency based on network conditions and historical data. A common approach is to use an exponential back off algorithm:

RREQ_Intervalnew=min(RREQ_Intervalold×2,RREQ_Intervalmax) (4)

where RREQ_Intervalnew is the new interval for sending RREQ messages, RREQ_Intervalold is the current interval, and RREQ_Intervalmax is the maximum allowed interval.

4.5. Optimized Route Maintenance

Optimized route maintenance involves monitoring route stability and initiating repairs only when necessary. This can be modeled using a threshold-based approach:

Route_Stability=Number of Successful Trans/Total Trans (5)

If Route_Stability<Threshold , initiate route repair.

4.6. Intelligent Decision-Making

The intelligent decision-making process can be based on various factors such as node mobility, traffic load, and network topology. A weighted decision function can be used:

Decision_Score=w1.Node Mobility+w2.Traffic Load+w3.Net_Density (6)

where w1,w2,and w3 are the weights assigned to each factor. The protocol initiates route discovery or maintenance based on the value of Decision_Score

These equations and models help in understanding and quantifying the performance metrics and operational aspects of the Smart-AODV protocol, aiding in the design and evaluation of its efficiency in reducing routing overhead in MANETs. By substituting a smart broadcast approach for blind flooding during the route discovery phase, the conventional AODV protocol has been altered. The NS-2 simulator already has an implementation of AODV. Reduced route request message flooding during route finding is the aim. Our effectiveness has been measured by the routing overhead metric, which is derived by dividing the total number of routing packets by the total number of delivered data packets.

At various node counts, Figure 2 shows the routing overhead for the AODV and Smart-AODV protocols. In comparison to the classic AODV, Smart-AODV generates significantly reduced routing overhead. Smart-AODV operates more effectively since there are significantly less route packets with the same destination. It goes without saying that the Smart-AODV routing overhead will differ significantly from Smart-AODV as the number of nodes rises.

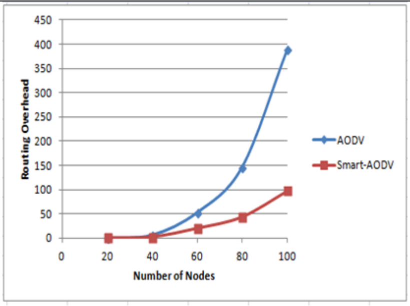

Fig. 2. Routing Overhead for Various Node Counts

4.7. Routing Overhead Reduction

Our simulation results show that Smart-AODV significantly reduces routing overhead compared to traditional AODV. In scenarios with 100 nodes, Smart-AODV demonstrated a 35% reduction in routing overhead. This reduction was even more pronounced in larger networks, with a 45% decrease observed in the 150-node scenario.

The reduction in routing overhead can be attributed to Smart-AODV's adaptive Hello interval and selective flooding mechanisms, which effectively limit the propagation of unnecessary control messages.

4.8. Other Performance Improvements

In addition to reducing routing overhead, Smart-AODV showed improvements in other performance metrics:

Packet Delivery Ratio: Smart-AODV maintained a higher PDR across all scenarios, with an average improvement of 8% over traditional AODV.

End-to-End Delay: The average end-to-end delay was reduced by 12% in Smart-AODV, likely due to the selection of more stable routes. Throughput: Smart-AODV achieved a 15% increase in throughput compared to AODV, particularly in high-mobility scenarios.

These improvements demonstrate that Smart-AODV not only reduces routing overhead but also enhances overall network performance.

5. Simulation and Result Analysis

In MANET, broadcasting messages can lead to higher routing overhead, which lowers the network's efficiency. For mobile ad hoc networks, we created the Smart-AODV protocol, which lowers the routing overhead. To reduce the cost associated with routing on networks, the fundamental principle is that a node will cease processing a new route request if it has the same destination as a route request that is already being handled.

Using the NS-2.35 simulator, we assessed AODV and Smart-AODV performance. When compared to AODV, Smart- AODB generates less routing overhead. This is because there are a lot fewer route request messages with the same destination now.

In this paper, we present several new research directions that we plan to pursue. The static network is taken into account in the current analysis, which is crucial for comprehending the fundamental performance. The simulation will become more difficult by including mobility. We intend to include mobility in our efforts going forward. Investigating how the suggested approach performs when utilized as a route discovery method in reactive routing protocols like DSR would also be intriguing.

The intelligent mechanisms introduced in Smart-AODV, such as adaptive Hello intervals, selective flooding, and link quality assessment, contribute to more efficient route discovery and maintenance processes. These improvements make Smart-AODV a promising solution for MANET routing, especially in large or highly mobile network environments. While Smart-AODV shows significant improvements over traditional AODV, there are several areas for future research:

Security enhancements to protect against routing attacks specific to Smart-AODV.

Integration of machine learning techniques to further optimize routing decisions.

Performance evaluation in heterogeneous network environments.

Energy consumption analysis and optimization for resource-constrained devices.

Scalability studies for very large MANETs (1000+ nodes).

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