STUDY AND DESIGN OF ON-DEMAND (REACTIVE) ROUTING PROTOCOLS FOR ROUTE MAINTENANCE FOR MOBILE AD HOC NETWORK (MANETs)

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ABSTRACT
Ad hoc wireless network is a collection of mobile nodes, forming a network. There is no centralized administration. Each host is an independent router. In ad hoc network, all the nodes move freely and independently, so topology is highly dynamic. To overcome the problems with proactive of small network, we proposed two Reactive routing protocols for route maintenance one is Reliable-AODV(R-AODV) & other is Efficient-DSR (E-DSR). Both R-AODV & E-DSR uses two levels of threshold to avoid the link breakage. Each node, that is the part of active, tests its own battery power and its neighbors’ RF signal periodically.

Keywords: Ad hoc network, Reactive Routing Protocol, R-AODV, E-DSR, RF signals.

1. INTRODUCTION
Wireless cellular systems have been in use since 1980s. We have seen their evolutions to first, second and third generation’s wireless systems. These systems work with the support of a centralized supporting structure such as an access point [1]. The wireless users can be connected with the wireless system by the help of these access points, when they roam from one place to other. The adaptability of wireless system is limited by the presence of a fixed supporting coordinate. It means that the technology cannot work efficiently in that place where there is no permanent infrastructure. Easy and fast development of wireless networks will be expected by the future generation wireless system. This fast network development is not possible with the existing structure of present wireless system. Recent advancements such as Bluetooth introduced a fresh type of wireless systems which is frequently known as mobile ad-hoc networks.

2. MOBILE AD-HOC WIRELESS NETWORK(MANET)
Ad-Hoc network can be considered as a special type of wireless mesh networks which is a collection of mobile wireless nodes forming any without any infrastructure or any standard services. Basically, an Ad-Hoc network is a temporary network connecting created for a special purpose (such as transferring data from one computer to another).Mobile Ad-Hoc Networks (MANETS) [2] are decentralized and mobile nodes act as router and also as host. If a Mobile node has to send the packets to other mobile nodes which are out of its range then the nodes within its range for forwards packets to the next hop until packets riches intended destination. Thus MANETS are also called multi-hop wireless networks. MANETS can be
setup between few nodes or can be extended by connecting to fixed network. Ad-Hoc Networks can be set up anywhere, any time. In mobile ad hoc networks the topology changes dynamically as nodes move in and out of each other’s range [3]. As ad hoc networks does not rely on pre-established infrastructure so mobile ad hoc networks can be deployed in places without any infrastructure. Due to the mobility of these nodes there are some characteristics that are only applicable to MANNET.

2.1 Characteristics of MANETS

a) Dynamic topology
b) Bandwidth-constrained, variable capacity Links
c) Energy-constrained operation
d) Limited physical security

2.2 Advantage of MANETS

a) They provide access to information and services regardless of geographic position.
b) These networks can be set up at any place and time

3. Existing Routing Protocols of AD-Hoc Networks

Since the advent of defense advanced Research Projects Agency (DARPA) packet radio network in the early 1970, numerous protocols have been developed for ad hoc mobile networks. Such protocols much deal with the typical limitation of these networks, which includes high power consumption, low bandwidth, and high error rates [4]. As shown in Figure below these routing protocols may generally be categorized [5] as:

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

![Ad hoc routing protocols](image)

*Figure 1: Types of Ad hoc routing protocols*

3.1 Multi-Hop AODV-2T

AODV-2T [6] uses two level of threshold and Main problem with AODV-2T is that it can perform only single hop route recovery. This limitation is overcome in Multi hop AODV-2T. In Multi hop AODV-2T [7], first upstream node try to do the local recovery (between upstream node of weal link and destination node), if local recovery is unsuccessful, only then it inform the source and take source appropriate action for route discovery.
3.1.1 Route-maintenance in Multi-Hop AODV-2T
The objective of Multi-hop AODV-2T is to enhance AODV-2T performance by extending its ability of creating a backup route to support Multi-hop partial route recovery. The approach is based on local repair mechanism of AODV-2T that has improved route maintenance in Ad hoc network by preparing backup route in a proper time. The mechanism works quite well in decreasing number of route breaks and then gains more network throughput.

4. Reliable Ad Hoc on Demand Distance Vector (R-AODV) Protocol
The proposed scheme description is based on AODV, to improve its performance. The major cause of route breakage in ad hoc wireless network is dynamic movement of mobile nodes themselves and other might be nodes running out of battery power. By considering these two factors, proposed scheme tries to involve only those nodes in the active route that have sufficient battery power (to ensure that our route do not break due to the failure of an intermediate node) and make sure that neighboring nodes of the established route are not too much far from each other. After the route gets established, proposed scheme tries to avoid its breakage by preparing a backup route just-in-time before the link breaking. In the proposed scheme, we have used two levels of threshold for each: node’s Battery power (BPOWER.TH1&BPOWER.TH2) and received Signal power (RF.TH2&RF.TH1), with TH2>TH1 in each case. We have frequently used the words upstream node (UN), downstream node (DN) and vulnerable node. To make our notations clear, we need to know that if the communication is from node ‘A’ to node ‘B’ then node ‘A’ is UN node ‘B’ is DN. Also a node whose battery power or/and received RF signal is less than higher level of defined threshold, is known as vulnerable node. To make our notations clear, we need to know that if the communication is from node ‘A’ to node ‘B’ then node ‘A’ is UN node ‘B’ is DN. Also a node whose battery power or/and received RF signal is less than higher level of defined threshold, is known as vulnerable node.

4.1 Route-discovery in R-AODV
Whenever source node S wants to communication with destination D and does not know its route, then S broadcast the RREQ packet to all of its neighbors, as in original AODV. Algorithm for the operations carried out by S broadcasting the RREQ packet is given in below table .Hence only those nodes whose battery power is greater than second level of battery threshold (BPOWER.TH2) and received signal power is greater than second level of received signal power (RF.TH2) can become the part of active route. This confirms that all the nodes in the active route have sufficient processing power and cannot fail too soon. Also by checking the node’s received signal (from its neighbors) power, we conforms that neighbor nodes in our established route are not too much far from each other. Hence route can’t break immediately due to node mobility (it is assumed that node movement speed is very slow). So our established route is more reliable.
Table 1: Route Discovery in R-AODV

4.2 Route-maintenance in R-AODV

Proposed scheme tries to prepare a backup route just-in-time before the link breaking. In proposed scheme, each node, that is part of active, checks its battery power and received signal power all the time. Whenever any node’s battery power or/and received signal power (node in the active route) drops to second (higher) level of defined threshold, it informs its UN as well as S about it by sending notifications. Upon receiving the notification, UN as well as S starts it the route discovery and the optimal discovered route becomes the primary route when first level of threshold (lower) is met.

4.3 Analytical justification for design of R-AODV

The following notations have been used:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meanings</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>Source Node</td>
</tr>
<tr>
<td>D</td>
<td>Destination Node</td>
</tr>
<tr>
<td>UN</td>
<td>Upstream Node</td>
</tr>
<tr>
<td>DN</td>
<td>Downstream Node</td>
</tr>
<tr>
<td>B POW. TH1</td>
<td>First (critical) level of battery threshold</td>
</tr>
<tr>
<td>B POW. TH2</td>
<td>Second level of battery threshold</td>
</tr>
<tr>
<td>B POW.TH2&gt;B POW.TH1</td>
<td>First level(critical) threshold of received RF signal power</td>
</tr>
<tr>
<td>RF.TH1</td>
<td>First level threshold of received RF signal power</td>
</tr>
<tr>
<td>RF.TH2&gt;RF.TH1</td>
<td>Second level threshold of received RF signal power</td>
</tr>
<tr>
<td>P1</td>
<td>Probability of finding the route b/w UN &amp; DN of active route.</td>
</tr>
<tr>
<td>P2</td>
<td>Probability of finding the route b/w source &amp; destination of active route.</td>
</tr>
<tr>
<td>T1</td>
<td>Time taken to find the route b/w source &amp; destination node of route R</td>
</tr>
<tr>
<td>T2</td>
<td>Time taken to find the route b/w source &amp; destination node of route R</td>
</tr>
<tr>
<td>T</td>
<td>Time taken for reducing the received signal power/battery power of a node from second threshold (TH2) to first threshold(TH1)</td>
</tr>
</tbody>
</table>
R1 | Backup route between S & D through the UN  
R2 | Backup route destination by S  

Table 2: notations used in Analytical justification for design of R-AODV

Following relationship will always hold:

$$P_2 > P_1 \text{  and  } T_2 > T_1$$

It is because scope of S is greater than UN while S will take much more time then UN to discover the route. We set the value of second and first thresholds in such a way that

$$T \geq T_1$$

i.e., we get the status of local backup route discovery before first level of threshold is met. To minimize the route breakage, (Probability of finding a backup route/time take for it) should be as high as possible. Since,

$$((P_1 \times P_2) / T_1 + ((1-P_1) \times P_2) / T_2) > \frac{(P_1) / T_1 + ((1-P_1) \times P_2) / (T_1+T_2)}{1}$$

L.H.S. of '> operator is used in R-AODV while R.H.S. is multi-hop AODV-2T. So route breakage probability in our proposed scheme is less than that in multi-hop AODV.

**Local Recovery is Successful** i.e. a path gets found between UN and DN of active route before actual link breakage:

**Case 1:** $T_2 \leq T$

- Hop count [R1] $\leq$ Hop count [R2]  
  Route discovered by UN becomes the primary route. So performance of our proposed scheme is same as that of multi-hop AODV-2T.
- Hop count [R1] $>$ Hop count [R2]  
  Since S has a more optimal route to D, so its backup route becomes the primary route, results in better performance than multi-hop AODV-2T.

**Case 2:** $T_2 > T$

Since S route discovery don’t get completed before actual link breakage, so the route discovered by UN becomes the primary route. Whenever S completes its route discovery process, it compares its discovered route’s hop count that of route R1. Hence proposed scheme would give same or better performance than multi-hop AODV-2T, depending upon whose hop count is greater.

**Local Route Discovery Fails** i.e. UN fails to find a route between it and DN before actual link breakage.

**Case 1:** $T_2 \leq T$

Since S had already found the route R2, so no route breakage occurs. R2 becomes the primary route. Our proposed scheme gives much better performance than multi-hop AODV-2T in this case; since in multi-hop AODV-2T, S would have completed route discovery after $T + T_2 + C$
time units, where C is time taken for the notification (about route failure) to travel from UN to S, instead of just T2 in our proposed scheme.

**Case 2: T2 > T**

A route breakage occurs at last. But performance of proposed scheme is better than that of multi-hop AODV-2T since S had started the route discovery much earlier than that started by S in multi-hop AODV-2T, hence route would be discovered earlier.

**4.4 Performance analysis of R-AODV**

We compare the performance of our proposed scheme i.e. R-AODV with multi-hop AODV-2T. Following cases are considered for evaluating the performance:

**Case 1:** In R-AODV, there is no danger of using long routes in a network because we always select the optimal route between route discovered by s & route discovered by UN. But in multi hop AODV and other previous efforts in this direction, active route can become suboptimal due to the use of repeated local repairing.

**Case 2:** In R-AODV, the probability of finding an alternate route before actual link breakage is more than multi-hop AODV-2T. Hence, R-ODV is more reliable.

**Case 3:** Data packets drop will be less in R-AODV then the multi-hop AODV-2T because in multi-hop AODV-2T, S starts the route discovery only after the local repair has becomes unsuccessful. Since S will also take some time to perform route discovery, so time interval between route breakage & route repair will be more in multi-hop AODV-2T then R-AODV( since in R-AODV, both perform the route discovery simultaneously).

Since data packets loss is directly proportional to time interval between route breakage & route repair, so data packets loss will be more in multi-hop AODV-2T then R-AODV.

**5. Efficient Dynamic source Routing (E-DSR) Protocol**

We have presented the operation details of the proposed scheme (Efficient-DSR). The proposed scheme is based on-DSR, to improve its performance. As we know in DSR, during the route discovery, a number of routes get discovered [8]. Only the optimal route among those routes, known as primary route, is used for sending the date packets. All other routes are kept as backup routes are kept as backup routes in route cache as shown in Figure. With the passage of time, these backup routes can become stale i.e., no longer exist.
5.1 Route Maintenance in E-DSR

In E-DSR, we have used two levels of threshold to avoid the link breakage. Each node, that is the part of route, tests its own battery power and its neighbors’ RF signal periodically. We try to check the freshness of all backup routes and try to discover a new route (if all backup routes are stale) before the link breaking. Each node that is the part of primary route, checks its battery power and received signal power all the time. Whenever any node’s battery power or/and received signal power (node in the primary route) drops two second (higher) level of defined threshold, it informs to the source (S) about it by sending notification. Upon receiving the notification, S start to check the freshness of all backup routes in its route cache & go on deleting those backup routes from its route cache, that are found to be stale as shown in figure. If the source route cache becomes empty, then source starts a new route discovery. When first level of threshold (lower) is met, then source check its route cache for a fresh breakup route, if there is any route in its cache, source make that route as the primary route. But if no route is found in the cache, source starts buffering of data packets till new route don’t get discovered.

5.2 Performance Analysis of E_DSR

Let there are ‘n’ backup routes in the route cache of source node ‘S’ & they are arranged in the increasing order of their hop_length.
\textbf{Tm} - Time interval for reducing the investigating factor of a node from Th2 to Th1.

\textbf{Pi} - Probability of freshness of route ‘i’; where “1 ≤ i ≤ n”.

\textbf{Ti} - Time required to ensure that ‘i\textsubscript{th}’ route is state or time required to send & receive special Control packet through route ‘i’.

\textbf{T} - Time to discover a new route.

\textbf{T n} - time required for checking the freshness of longest backup route.

\textbf{T p} - Difference b/w Tm and Tn. (Tm-Tn)

\textbf{T\textsubscript{DSR}} - time delay b/w breakage of primary route and finding of a new primary in DSR

Probability that \textit{i}\textsuperscript{th} backup route is fresh, but all routes before it are stale:

\[
P_{A} = \left[ \prod_{k=1}^{i-1} (1-Pk) \right]^{n} \cdot Pi
\]

Probability that all backup routes are stale:

\[
P_{B} = \left[ \prod_{k=1}^{n} (1-Pk) \right]
\]

Probability that at least one backup is fresh:

\[
P_{C} = \left[ 1 - \prod_{k=1}^{n} (1-Pk) \right]
\]

\& $P_{C} > P_{A}$

\[
T_{DSR} = \begin{cases} 
\sum_{k=0}^{i-1} Tk; \text{with probability } P_{A} \& P_{0} \ldots \ldots \ldots \ldots (1) \\
[\sum_{k=1}^{n} Tk] + T; \text{With probability } P_{B}
\end{cases}
\]

Where $\sum_{k=0}^{i-1} Tk$ Gives the time delay after which source ‘S’ starts sending data packets through \textit{i}\textsuperscript{th} route in route cache.

\textbf{Proposed E-DSR}

\[
T_{E-DSR} = \begin{cases} 
O; \text{with probability } P_{C} \& P_{C} > P_{A} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots 
\end{cases}
\]

From equation (1) & (2), $T_{E-DSR} < T_{DSR}$

Since data packets loss is directly proportional to time interval between route breakage & route repair, so data packets loss will be more in normal – DSR than E-DSR.
Since, dropped data packets (D.D.P) are directly proportional to the Time delay for finding new fresh route from equation(1) & equation (2), we observe that in case of our proposed protocol ‘E-DSR’, time delay is much less than ‘normal-DSR’, so less packets will get dropped (lost) or PDF (packet delivery fraction) will increase with our scheme. So, with the help of our proposal both the performance matrices PDF is increased as compared to normal-DSR scheme and also very less time-delay to prepare new fresh route after actual link breakage.

6. CONCLUSION AND FUTURE WORK

In this work we proposed two schemes:- R-AODV, E-DSR.R-AODV has been proposed to improve the route maintenance process of AODV. In R-AODV, we use two levels of threshold (Th1 & Th2) to prepare a back up route before just the actual route breakage. When the higher level of threshold (i.e., TH2) is met for any node in active route, route discovery is initiated by the upstream node of that node as well as by source node

E-DSR has been proposed to improve the route maintenance process of DSR. As in R-AODV, We use two levels of thresholds of thresholds in E-DSR. The higher level of threshold is used to find optimal fresh back-up route from source’s route cache, if available. If there is no fresh route, then source starts new route discovery before actual breakage of primary route by analyzing our schemes, we get that R-AODV and E-DSR decreases the number of dropped data packets i.e. increases the PDF and reduces average end to end delay, in AODV and DSR respectively.

In future, this dissertation work can be extended by simulating these schemes in NS-2 simulator.

REFERENCES


