Route Repair in Mobile Adhoc Networks

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Guide

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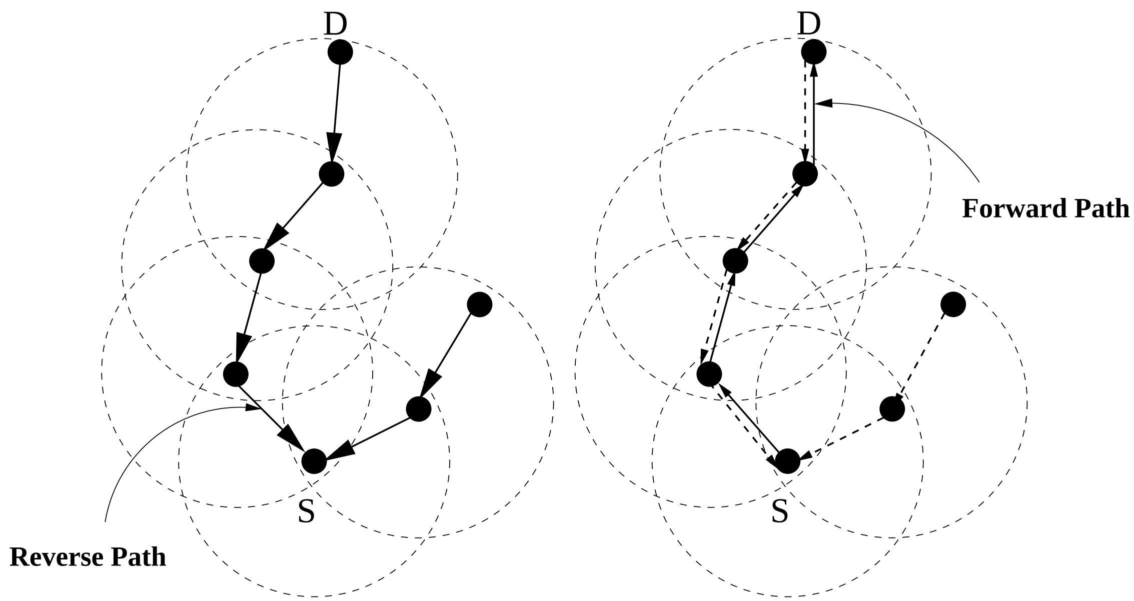
Mobile Adhoc Networks

- **Characteristics**
  - Cooperative engagement of Mobile Hosts
  - No pre-existing communication infrastructure
  - Multihop Network
  - Bandwidth and Power constrained
  - Military and Disaster relief operations
- **Routing Protocols**
  - Proactive : DSDV
  - Reactive : AODV , DSR
  - Hybrid : Kelpi

Adhoc On Demand Routing Protocol (AODV)



- RREQ : Route Request
- RREP : Route Reply
- RERR : Route Error

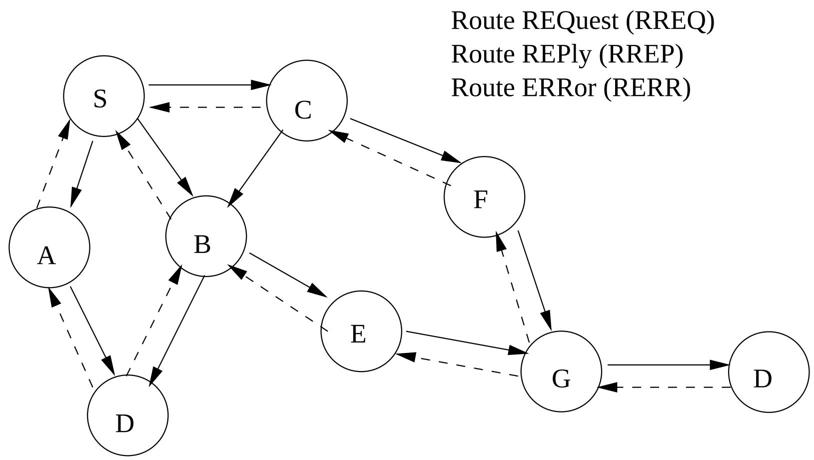
Route Repair in Reactive Routing Protocols

- Flag an error and re-initiate route discovery
- Routing overhead
  - Result of error broadcasts followed by flooding in the route discovery phase
- Delay
  - Inability to find alternative route without re-initiating route discovery

Problem Statement

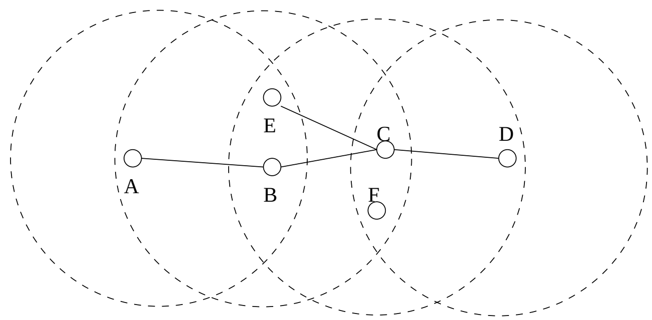
Find an effective technique to reduce routing overhead and delay during route repair in Mobile Adhoc Networks.

Local Route Repair (LRR)



- Initiates Route discovery at the intermediate node.
- Success
  - sends a RERR message to the source with the 'N' flag set.
- Failure
  - sends a RERR message to the source and re-initiates route discovery at the source

Routing Handoff



- Proactive approach
- Find a node in the neighborhood to take the task of routing packets routed through a link which is about to break
- HREQ : Handoff Request
- HREP : Handoff Reply

Packet Format of HREQ and HREP

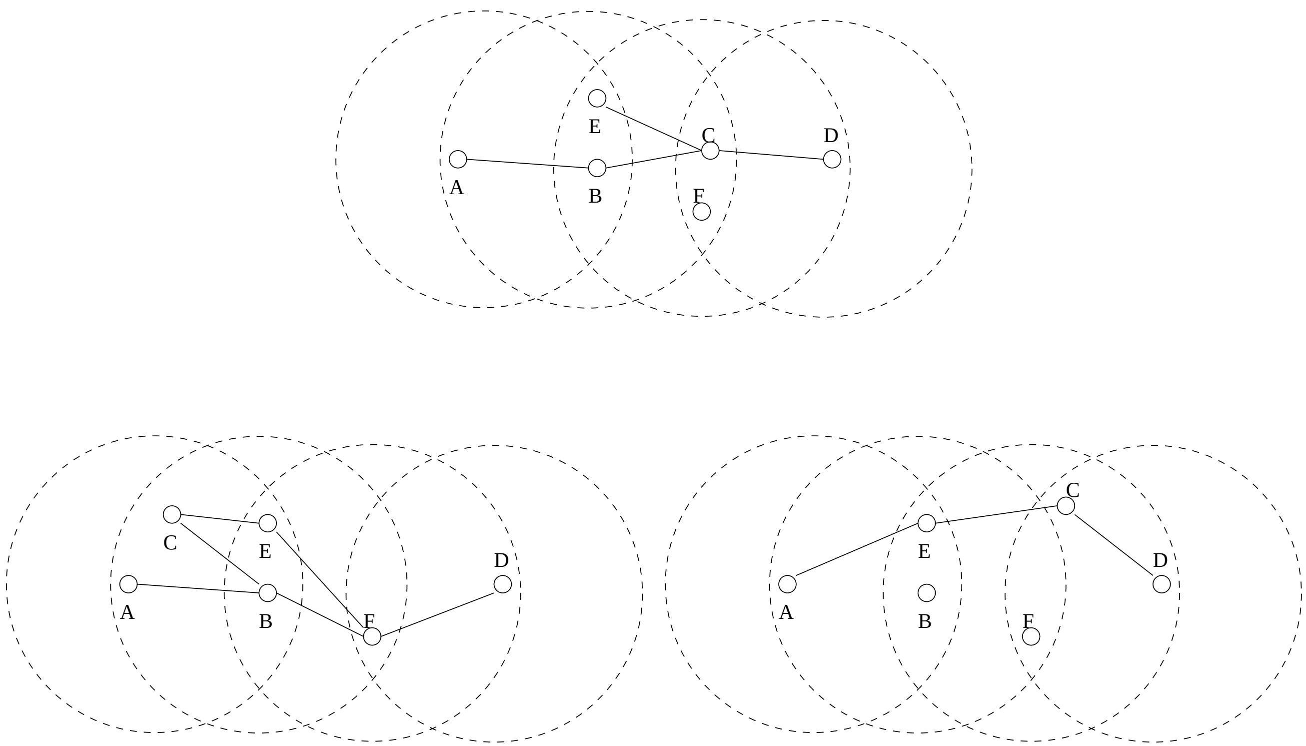
0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7

Type	Reserved	Hop Count
Broadcast ID		
IP address of the Node		
Unreachable Next Hop (UNH) IP address		
Active Previous Hop (APH) address (1)		
IP address of the destination which uses UNP and receives packet from APH (1.1)		
IP address of the destination which uses UNP and receives packet from APH (1.2)		
IP address of the destination which uses UNP and receives packet from APH (1.x)		
Active Previous Hop (APH) address (y)		
IP address of the destination which uses UNP and receives packet from APH (y.1)		
IP address of the destination which uses UNP and receives packet from APH (y.2)		
IP address of the destination which uses UNP and receives packet from APH (y.z)		

0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7 0 1 2 3 4 5 6 7

Type	Reserved	Hop Count
Broadcast ID		
IP address of the Node		
Unreachable Next Hop (UNH) IP address as in HREQ		
IP address of the Node which broadcast the HREQ		
IP address of the destination which uses UNP and receives packet from APH (1)		
IP address of the Active Previous Hop in HREQ that sends pkt dst 1 (1.1)		
IP address of the Active Previous Hop in HREQ that sends pkt dst 1 (1.2)		
IP address of the Active Previous Hop in HREQ that sends pkt dst 1 (1.x)		
IP address of the destination which uses UNP and receives packet from APH (y)		
IP address of the Active Previous Hop in HREQ that sends pkt dst 2 (y.1)		
IP address of the Active Previous Hop in HREQ that sends pkt dst 2 (y.2)		
IP address of the Active Previous Hop in HREQ that sends pkt dst 2 (y.z)		

Routing Handoff



Algorithm

```
Begin
                              .
                              .
                              .
      if((Power of Received Packet/Threshold Power) < HTH) {
            Create Handoff Request Packet;
            Send Handoff Request Packet;
      }
      if(Received Packet == Handoff Request) {
            Check Neighbor Information Table;
            if(Next Hop Node in HREQ is a Neighbor) {
                  if(Any Previous Hop Node in HREQ is a Neighbor) {
                        Update Routing Table;
                        Create Handoff Reply Packet;
                        Send Handoff Reply Packet;
                  }
            }
      }
      if(Received Packet == Handoff Reply) {
            if(Handoff Reply is for this Node) {
                  Update Routing Table;
            }
      }
                              .
                              .
                              .
End
```

Computation of Handoff Threshold

- t time required for routing handoff
- s maximum speed of the node
- d distance to covered before handoff is to take place

$$\frac{\text{RxPr}}{\text{RxThresh}} \leq \text{HTH} \tag{1}$$

$$\text{Received Power} \propto \frac{1}{\text{distance}^4}$$

$$\text{RxThresh} \propto \frac{1}{\text{R}^4} \tag{2}$$

$$\text{RxPr} \propto \frac{1}{(\text{R - d})^4} \tag{3}$$

Substituting 2 and 3 in equation 1 we get

$$\frac{\text{R}^4}{(\text{R - d})^4} \leq \text{HTH} \tag{4}$$

$$\frac{\text{R}^4}{(\text{R - (s} * \text{t}))^4} \leq \text{HTH} \tag{5}$$

Modeling a Mobile Adhoc Network

- **Model**
  - A : Area of the Network
  - N : Number of Nodes
  - R : Range of Transmission
  - ϕ : Routes affected by broken link
- **Basic Results**
  - Average Path Length : $\overline{L} = \frac{2\sqrt{A}}{3}$ [Jinyang Li, Mobicom2001]
  - Average Hops : $H = \frac{2\sqrt{A}}{3R}$
  - Flooding Packets : N
- **Parameters**
  - PKT : No of packets involved in repairing a broken link
  - DEL : Delay involved in repairing a broken link

Analysis of AODV

1. Number of packets involved in repairing a broken route (PKT)
   Number of packets involved in repairing a broken route = RERR broadcast to the sources affected + flooding to discover the route for each route+ RREP unicast from the destination to the source

$$\begin{aligned} PKT &= K + \phi N + \phi H \\ &= \frac{\phi\sqrt{A}}{3R} + \phi N + \phi\frac{2\sqrt{A}}{3R} \end{aligned} \tag{6}$$

2. Delay involved in repairing a broken route (DEL)
   Delay involved in repairing a broken route = RERR broadcast to reach the source + RREQ to reach the destination + RREP to reach the source

$$\begin{aligned} DEL &= k + H + H \\ &= k + 2H \\ &= \frac{\sqrt{A}}{3R} + \frac{4\sqrt{A}}{3R} \\ &= \frac{5\sqrt{A}}{3R} \end{aligned} \tag{7}$$

Analysis of LRR

1. Number of packets involved in repairing a broken route (PKT)
   Number of packets involved in repairing a broken route = RERR broadcast + flooding to discover the route for each route + RREP unicast from destination to the intermediate node

$$
\begin{aligned}
PKT &= K + \phi N + \frac{\phi\sqrt{A}}{3R} \\
&= \frac{\phi\sqrt{A}}{3R} + \phi N + \phi\frac{\sqrt{A}}{3R} \qquad (8)
\end{aligned}
$$

2. Delay involved in repairing a broken route (DEL)
   Delay involved in repairing a broken route = RREQ to reach the destination + RREP to reach the intermediate node

$$
\begin{aligned}
DEL &= \frac{H}{2} + \frac{H}{2} \\
&= H \\
&= \frac{2\sqrt{A}}{3R} \qquad (9)
\end{aligned}
$$

Analysis of Routing Handoff

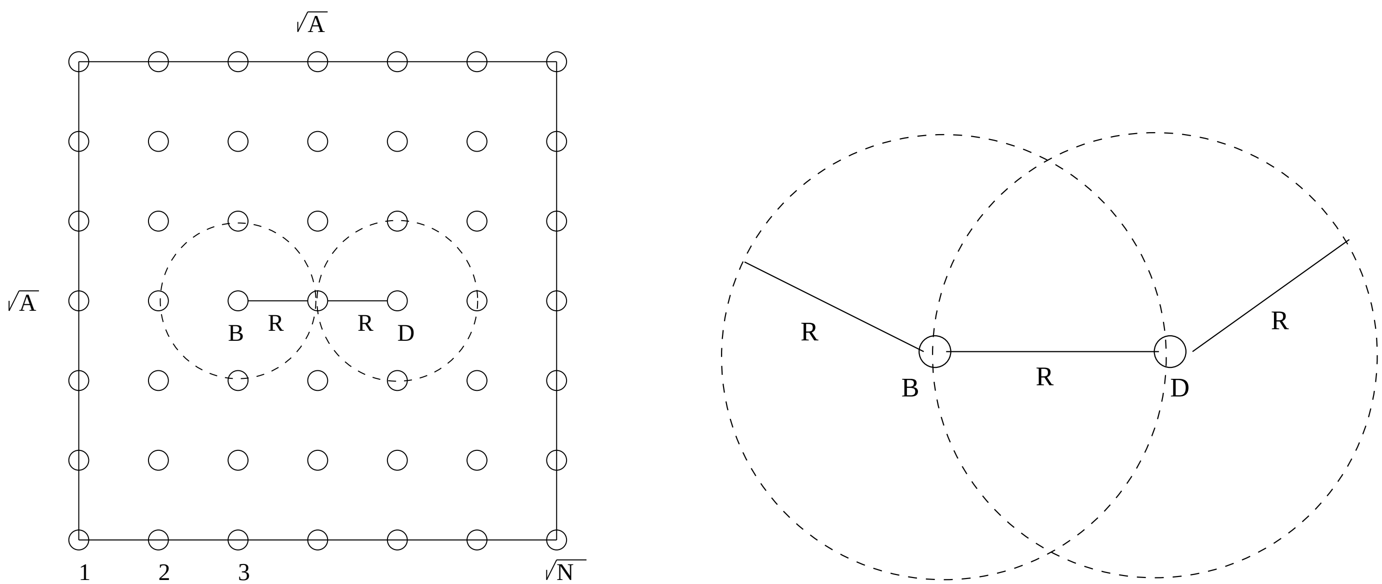
1. Number of packets involved in repairing a broken link (PKT)
   Number of packets involved in repairing a broken link = HREQ + HREP

$$\begin{aligned} PKT &= 1+1 \\ &= 2 \end{aligned} \tag{10}$$

2. Delay involved in repairing a broken link (DEL)
   Delay involved in repairing a broken link = HREQ + HREP

$$\begin{aligned} DEL &= 1+1 \\ &= 2 \end{aligned} \tag{11}$$

Criteria for Routing Handoff



$$R > \frac{\sqrt{A}}{\sqrt{N}} \qquad \eta \leq \frac{1.23R^2N}{A} \text{ and } \eta \geq 2$$

$$\Rightarrow \quad N > \frac{A}{R^2} \qquad N \geq \frac{\eta A}{1.23R^2}$$

Simulation

- Network Simulator
- C++ and OTcl
- AODV and Local Route Repair already implemented
- Routing Handoff Implemented
  - sendHandoffRequest
  - recvHandoffRequest
  - sendHandoffReply
  - recvHandoffReply

Simulation...

- HRQ_ID : parameter which restricts the number of HREQ sent
- HRP_ID : parameter which restricts the number of HREP received.
- 25 Nodes and 50 Nodes
- 100 mts Range
- RxThresh = 1.76125e-10
- Slow Mobility
  - MinPause = 5 sec, MaxPause = 10 sec, MinSpeed = 20 m/sec, MaxSpeed = 40 m/sec , HTH = 3
- High Mobility
  - MinPause = 1 sec, MaxPause = 2 sec, MinSpeed = 40 m/sec, MaxSpeed = 600 m/sec , HTH = 6

25 Nodes (500 x 500)

TCP connections	AODV	LRR	HANDOFF
10	7331176	8163728	8624528
15	8115248	7381080	8819880
20	8419144	7784432	8453920

TCP packets received for 25 Nodes (low mobility)

TCP connections	AODV	LRR	HANDOFF
10	39082	42038	41422
15	43347	43305	43841
20	44890	43335	44651

Routing overhead (pkts) for 25 Nodes (low mobility)

TCP connections	AODV	LRR	HANDOFF
10	99.5944	99.3829	99.1753
15	98.8947	99.1456	99.0845
20	98.7148	99.2536	99.0334

Throughput (%) for 25 Nodes (low mobility)

25 Nodes (500 x 500)

TCP connections	AODV	LRR	HANDOFF
10	7497656	7090576	7723448
15	7679576	7709784	8686680
20	8094536	7716790	7973664

TCP packets received for 25 Nodes (high mobility)

TCP connections	AODV	LRR	HANDOFF
10	39570	40895	39804
15	43484	43844	44536
20	42933	43419	44801

Routing overhead for 25 Nodes under (high mobility)

TCP connections	AODV	LRR	HANDOFF
10	98.9254	99.0406	99.4457
15	98.716	99.4093	98.6894
20	98.6199	98.375	98.5048

Throughput (%) for 25 Nodes under (high mobility)

50 Nodes (700 x 700)

TCP connections	AODV	LRR	HANDOFF
20	6305528	5724408	7001456
30	7288416	6745776	7569112
40	7991400	6737080	7962256

TCP packets received for 50 Nodes (low mobility)

TCP connections	AODV	LRR	HANDOFF
20	43125	45894	45389
30	48957	48691	49351
40	52061	52234	52326

Routing overhead (pkts) for 50 Nodes (low mobility)

TCP connections	AODV	LRR	HANDOFF
20	98.6335	98.3769	98.6997
30	97.3548	98.2126	98.5361
40	98.1511	98.4879	98.1073

Throughput (%) for 50 Nodes (low mobility)

50 Nodes (700 x 700)

TCP connections	AODV	LRR	HANDOFF
20	7085696	5631656	7343312
30	6949472	7080072	7585968
40	6898712	5927256	7544856

TCP packets received for 50 Nodes (high mobility)

TCP connections	AODV	LRR	HANDOFF
20	46882	48924	45949
30	52136	54186	56408
40	53167	55037	56670

Routing overhead (pkts) for 50 Nodes (high mobility)

TCP connections	AODV	LRR	HANDOFF
20	97.5571	97.0997	97.6469
30	96.7787	98.6673	97.6422
40	96.3518	97.4998	96.8943

Throughput (%) for 50 Nodes (high mobility)

50 Nodes (850 x 850)

TCP connections	AODV	LRR	HANDOFF
20	5960912	6338336	6078240
30	8108168	7519288	7686200
40	7592632	7989944	7544896

TCP packets received for 50 Nodes (low mobility)

TCP connections	AODV	LRR	HANDOFF
20	48572	53726	44473
30	54584	54146	53557
40	57792	63480	57407

Routing overhead (pkts) for 50 Nodes (low mobility)

TCP connections	AODV	LRR	HANDOFF
20	97.8452	98.152	96.6441
30	98.1356	98.357	97.9166
40	97.533	98.0815	97.786

Throughput (%) for 50 Nodes (low mobility)

50 Nodes (850 x 850)

TCP connections	AODV	LRR	HANDOFF
20	7088928	6647112	7508768
30	6901304	64328376	6328376
40	6845264	6749008	6519672

TCP packets received for 50 Nodes (high mobility)

TCP connections	AODV	LRR	HANDOFF
20	48586	46438	47702
30	51642	53469	53590
40	54965	56271	52438

Routing overhead for 50 Nodes (high mobility)

TCP connections	AODV	LRR	HANDOFF
20	96.8709	97.6809	97.64
30	96.6593	96.7083	96.8429
40	96.2848	97.1465	96.8833

Throughput (%) for 50 Nodes (high mobility)

Conclusion

- Routing Handoff performance is better than local route repair when the network confirms to the routing handoff criteria.
- Routing Handoff performance is comparable or better than AODV when the network confirms to the routing handoff criteria.
- Routing Handoff performance becomes erratic with respect to AODV and LRR when the routing handoff criteria is violated.
- Routing Handoff performance varies with parameters like HTH, HRQ_ID and HRP_ID.
- It is difficult to predict the values of HTH, HRQ_ID and HRP_ID for which routing handoff would provide the best performance.

Future Work

- Theoretical/Heuristic approach to estimate parameters like HRQ_ID and HRP_ID
- Investigate the benefits of routing handoff in other routing protocols

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