Poster: Utilizing Resource-rich Nodes in Ad hoc Networks

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ABSTRACT

In wireless ad hoc networks heterogeneity is inherent; each node has different characteristics, resources and purpose. Current ad hoc routing protocols do not take node heterogeneity into account when making routing decisions; they consider each node identical in capabilities. We propose a simple way to modify the route discovery phase of an on-demand routing protocol to choose the "best" route, considering heterogeneity. The Ad hoc On-Demand Distance Vector Routing protocol (AODV) [1] is modified and the performance validated in experimental tests. It is shown that by considering heterogeneity during route discovery, paths that contain more capable nodes are utilized, thereby avoiding resource-poor nodes.

Categories and Subject Descriptors

C.2.2 [**Computer-Communication Networks**]: Network Protocols - *Routing Protocols*

General Terms

Design, Performance, Experimentation

Keywords

Ad hoc Networks, Mobile Networks, Heterogeneous Routing

1. INTRODUCTION

Today's wireless networks consist of many different devices. In such networks with many mobile heterogeneous devices and little or no infrastructure, the network topology will change frequently. Ad hoc routing protocols will be used because of their ability to easily deploy and quickly adjust to network changes. For these reasons it is easy to imagine an ad hoc wireless network being deployed in a public place, composed of some dedicated wireless routers, desktop machines, laptops, handhelds and phones (see figure 1). Each device in the network has it's own characteristics, properties and purpose and should be used accordingly.

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Figure 1: Example Heterogeneous Ad hoc Network.

In current on-demand ad hoc routing protocols, all devices are considered equal when making routing decisions. That is, the likelihood of a resource-poor (weak) device forwarding data packets is the same as that of a resource-rich (strong) device. In a heterogeneous network those nodes that are weak should be avoided, if stronger devices can be used instead. Using the method presented here packets will be forwarded by the strongest route, considering node heterogeneity.

In this summary we present Heterogeneous Biased Route Discovery (HBRD), a method to bias on-demand route discovery to avoid weak nodes.

2. PROBLEM SCENARIOS

Consider a heterogeneous network, as shown in figure 2, where AODV is being run by all the devices. If the two mobile phones wish to communicate, the likelihood that the route chosen will be through the laptop or through the handheld is the same. The selection of the device (handheld or laptop) will be fairly random in this scenario. In this situation, if heterogeneity is considered and weak devices such as the handheld are avoided, traffic between the two phones should be routed through the laptop.

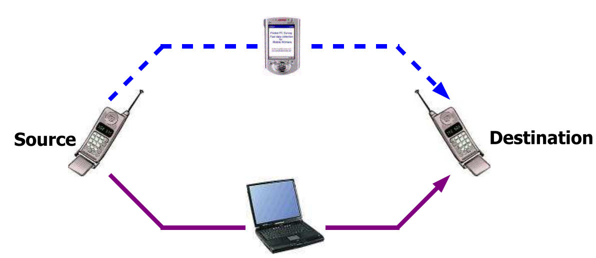

Figure 2: Four Node Scenario.

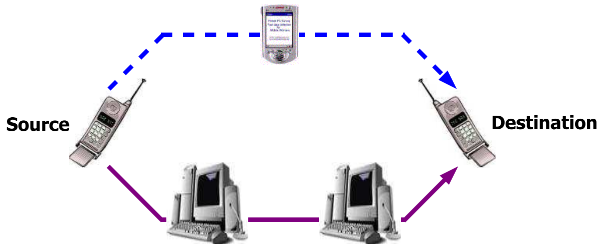

Figure 3: Five Node Scenario.

In many heterogeneous networks it may be appropriate for the two phones to communicate via a longer path in order to avoid routing data via a weak device, such as a handheld, so that the battery of the weak device can be conserved. In figure 3 there are two available paths, one through the handheld and the other through two desktop machines. In this scenario, using AODV, the handheld will be chosen as the route through which the two phones communicate. There is no way for the handheld to avoid routing packets between the two phones. Because the handheld is a resource-poor device, it is beneficial to route all data through the two computers. In this way the handheld is spared from routing packets between the two phones. HBRD provides a simple way to bias route discovery so that the route chosen between the two phones will avoid the handheld.

3. HETEROGENEOUS BIASED ROUTE DISCOVERY

Recall in figure 2 the handheld and laptop have the same probability of being chosen on a route between the two phones. The reason for the handheld and laptop having the same probability of being on the route selected by AODV is because the propagation time of the route request (RREQ), from source to destination, is nearly equal. We propose introducing additional delay during the propagation of the RREQ through the network in weak nodes. Consequently, RREQs in routes without delay will reach the destination first and routes with weak nodes will be avoided. The RREQ delay introduced by a weak node should be inversely proportional to its willingness to participate; the more adverse a weak node is to being on the chosen route, the larger the delay it should utilize.

Consider in figure 2, if the handheld delays its rebroadcast of the RREQ, the destination will receive the RREQ from the laptop first. Therefore the route through the laptop is chosen and the handheld is spared from participating on this route.

For this technique to function properly the destination must use minimum-delay as the routing metric for RREQs. Also the destination must be the only node to respond to the RREQ and respond only to the first RREQ it receives. Otherwise, if multiple RREPs are received by the source then the route selection will not be based on the minimum delay, but instead on the minimum hopcount. It is also possible for packets to collide or be dropped during route discovery. If this occurs, the route discovery may not choose the most resourceful route, but will still choose the minimum-delay route.

Number of Nodes	Route Discovery Protocol	Handheld Chosen	Handheld Not Chosen
4	AODV	50%	50%
4	HBRD	0%	100%
5	AODV	100%	0%
5	HBRD	0%	100%

Table 1: Experimental Results.

4. EXPERIMENTAL VALIDATION

To evaluate HBRD we modified an existing AODV implementation to include HBRD. This implementation allowed us to run experiments on real hardware as well as simulations examining the effectiveness of HBRD. The results show that HBRD does indeed bias routes toward more capable nodes, with minimal impact to performance metrics.

In our experimental testbed all the nodes were Pentium III laptops running Linux 2.4. Each was equipped with a Lucent Orinoco wireless card set to communicate at 2 Mbps. They were all located on the same desk and connectivity was controlled using the MAC layer filtering program *iptables*. Each test was run 10 times.

Testbed experiments with the same configuration as figures 2 and 3 were run. Though all the devices here are identical, each device could be configured with a static delay value. The laptop representing the handheld was given a delay value greater than the processing time of two hops. No other devices introduced delay.

When route discovery occurs, the RREQ in the laptop representing the handheld is delayed. This causes the RREQ rebroadcast by the other route to be received by the destination sooner than the RREQ rebroadcast by the handheld. Because the destination only responds to the first RREQ received, the laptop representing the handheld is avoided and the other route is chosen. The results in table 1 show that in the four node scenario in figure 2, without HBRD, the route through the handheld and laptop are chosen equally. The results also show that when HBRD is used the handheld is avoided.

Now examining the scenario with five nodes as shown in figure 3 with unmodified AODV, the route through the handheld is always chosen. However, as table 1 shows, with HBRD the route through the two laptops is chosen.

5. CONCLUSION

In this summary we presented HBRD, a simple method to bias on-demand route discovery toward resource-rich routes by using delay during route discovery propagation. Experimental results show HBRD successfully selects routes according to node resources. Using HBRD, nodes may reduce their participation in routing to conserve their resources.

6. ACKNOWLEDGMENTS

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7. REFERENCES

[1] Charles E. Perkins and Elizabeth M. Royer. The Ad hoc On-Demand Distance Vector Protocol. In *Ad hoc Networking*, pages 173–219. Addison-Wesley, 2000.