New Flooding Control Schemes Applied In Route Initialisation For The Ad Hoc On Demand Routing Protocols

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Abstract: This paper introduces a new route request flooding control scheme, called Pre-location Oriented Routing for the Ad Hoc On Demand Routing protocols. This scheme aims to control and reduce the route request flooding. Furthermore, the scheme combines the strength of Clustering Structure Routing to make the flooding mechanism more efficient and increase the route establishment speed.

1. Introduction

An ad hoc network is a collection of wireless nodes dynamically forming a temporary network without the use of any existing network infrastructure or centralized administration, characterized by node mobility, dynamic topology structure, scarce bandwidth, unreliable media and limited power supply. Nodes in an ad hoc network must cooperate and carry out a distributed routing protocol in order to make multi-hop communications possible.

First and foremost, an effective ad hoc routing protocol should perform acceptably in such a critical environment. Since bandwidth and power consumption are scarce, Proactive protocols (e.g. DSDV) that do the precomputation of all routes may not be feasible. Thus, it may be useful to use an On Demand (e.g. DSR, AODV, etc) approach to routing, where routes are not computed until there is data that needs to be sent [1,2, 4]. In recent years, a vast study has been conducted on the On Demand protocols. Nevertheless, lots of problems still exist. The route request flooding and route discovery delay are two explicit problems for the protocols. This paper introduces 2 flooding control schemes to minimise the problems.

2. Issues for the Conventional Flooding Scheme

For the On Demand protocols, the most common procedure for initialising a new route is to broadcast route requests (RREQs) to all the neighbours, and the RREQs are relayed by intermedia nodes to the destination, Figure 1. The route reply (RREP) is sent back from the intermedia nodes that have the route information or the destination node itself. When a new route is successfully established, the route will be stored in the source node and the relay nodes for a short period (ROUTE_LIFE_TIME); the route will be expired and erased after this period. If a connection is called for the same destination, but the route has already been erased, the same RREQ flooding procedure has to be carried out again [1, 2, 3, 6].

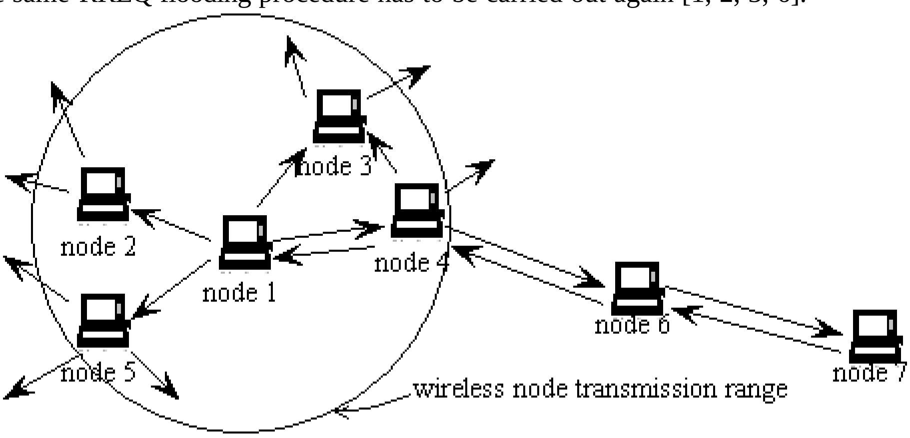


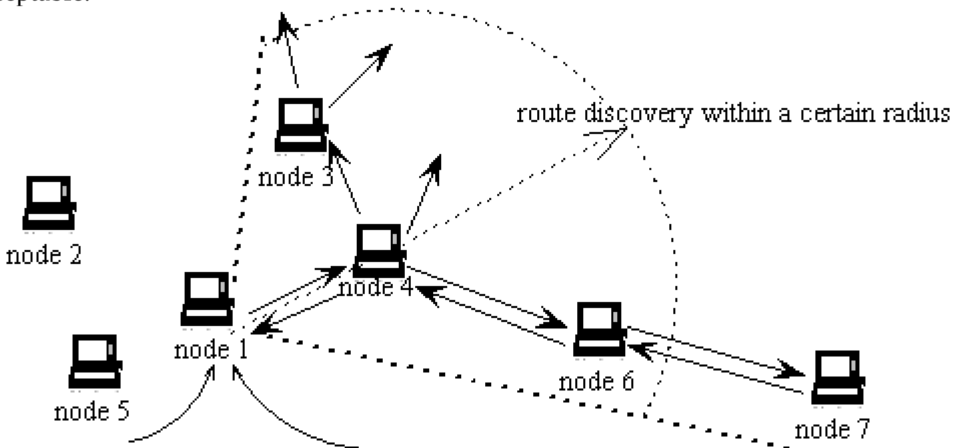
Figure 1: A conventional On Demand RREQ flooding

Because of the RREQ flooding scheme, the conventional routing initialisation can be very costly in On Demand networks in terms of network throughput efficiency, node energy, as well as route discovery time.

For the new proposed protocols, flooding control is provided: Duplicates are detected by each receiving node and are immediately discarded in order to avoid endless looping; RREQ carries Time-To-Live (TTL), which represents the maximum hop that the packet can traverse.
In spite of the control mechanisms above, flooding generates replicated packet arrivals to each node; namely, one replica for each neighbour. Thus, flooding overhead corresponding to replicated, redundant packets increases with connectivity. Flood search is the capstone of all On Demand routing protocols. These protocols need to find a path on demand. Since one generally assumes that there is no relative geographical positioning infrastructure that can guide the packet to destination, a path search query must be flooded to the entire network. The main reason of this problem is that the RREQ flooding scheme has no direction orientation.

3. Pre-location Oriented Routing Scheme

From the above analysis of the conventional On Demand routing, we may notice that even if the route is expired, the destination node may still be within the same radius as before, especially for the low and medium mobility situation. But the routing initialisation doesn't notice that the RREQ packets are rebroadcasted unnecessarily for all the directions (redundant rebroadcast).
Imagine that the nodes are aware of the destination positions within a certain error. This information can be easily used to orient the new route initialisation! A new routing scheme, which I call "Pre-location Oriented Routing Scheme", can achieve this. As the name indicates, the previous location/route of the destination orients the exploration for new routes. The basic idea is that a source node, which needs to find a route to a destination, remembers where the destination was last "seen" and localizes its route discovery query to within a radius of that previous location.
The implementation follows this process: when the route is expired, the node stores the next hop for the destination in an extra table instead of erasing it immediately. When new routes need to be set up to the same destination, the source node can send RREQ to the corresponding next hop by looking it up in the table, Figure 2, instead of flooding the RREQs to all the neighbour nodes as in the conventional On Demand protocols.
With respect to the limited memory space and the mobility of the nodes, the extra table should just store the destination node id and the corresponding next hop id. It should also have a lifetime: the route will be deleted at the end of its lifetime.
If the Pre-location Oriented Routing fails (i.e., the destination node moved far away from the previous area), the rest of the neighbour nodes have to be flooded by RREQs.
To carry out the Pre-location Oriented Routing Scheme, extra memory space and CPU calculation time are needed. But comparing with the high proportion reduction of the RREQ flooding packets, these costs are little and acceptable.



Routing Table

node	hop	hop	…	life time
…	…	…	…	…
7	4	6	…	u
…	…	…	…	…

Extra Table for pre-location orienting

node	next hop	life time
1	1	x
…	…	…
7	4	y

Figure 2: Pre-location Oriented Routing

4. Clustering Structure Routing

In order to further reduce the RREQ flooding as well as increase the route establishment speed, the Pre-location Oriented Routing can combine the strength of Clustering Structure Routing [4]. This idea is based on a 2 hops clustering structure. To illustrate this concept, let's consider the *n* node example in Figure 3. Let *r* be a transmission range, and the size of the roaming space be

$$\frac{k}{\sqrt{2}}r * \frac{k}{\sqrt{2}}r$$

Where k is an even number (Figure 3 depicts the case of k = 6). There are n nodes in the square, but in the figure it only show the nodes at coordinates

$$(\frac{a}{\sqrt{2}}r, \frac{b}{\sqrt{2}}r),$$

where either a or b is an integer smaller than k. This "selection" of nodes is known as "two hop clustering", i.e., any two nodes in a cluster are separated by at most two hops. The nodes at the centre of the circles are "cluster heads" and the light shaded nodes in between are "gateways." Clearly, such nodes represent a connected set. They are in fact the dominant set required to forward the flood packets. Without the cluster overlay shown in Figure1, each flood packet is relayed exactly n-1 times, as each node must rebroadcast the packet once. On the other hand,

$$(k-1)*\frac{k}{2}+\frac{k}{2}*(\frac{k}{2}-1)=\frac{k(3k-4)}{4}$$

broadcasts suffice if only cluster heads and gateways forward the packet. Note that in the cluster restricted forwarding, ALL nodes still receive the flood packet. The flooding reduction is thus

$$\frac{\frac{k(3k-4)}{4}}{n-1}.$$

In a case of n = 100 and k = 6, the number of broadcasts required in the cluster is 21 instead of 99. In other words, 78.8% of transmissions can be saved, although this is not a very dense network (each node has about 12 neighbours). As we increase the number of nodes in the system (and therefore the density), the clustering structure and thus the broadcast remain the same. As a result, the saving increases with the node density. For the high-density network, the Clustering Structure Routing scheme should cut down the RREQ flooding and route establishment time significantly.

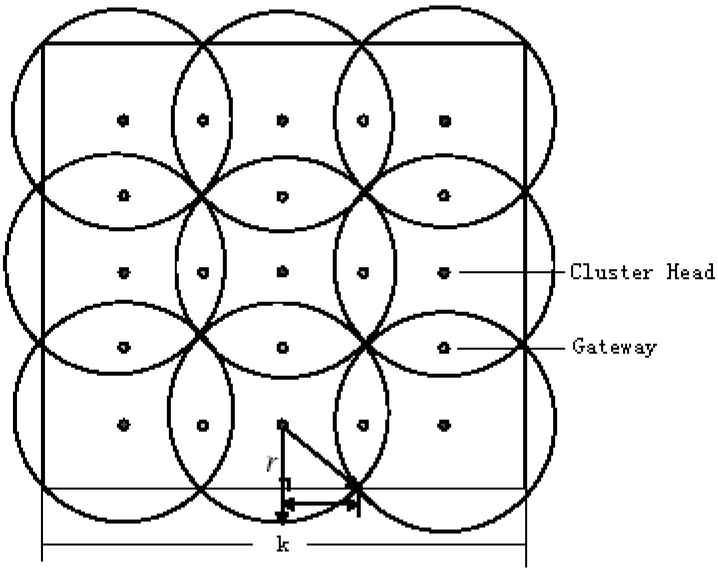


Figure 3: the network structure when k=6

The implementation of the clustering structure is quite complicated. First, the network has to be structured by setting the appropriate Cluster Heads and Gateways. Because of the mobility of the network, Cluster Heads and Gateways may change frequently. This requires every node in the network to have certain knowledge of its position. To achieve this, the position information is transmitted by the 'hello' message or some extra location packets. After the Cluster Heads and Gateways for the network are structured, we can directly apply the same On Demand routing protocol and the Pre-location Oriented Routing Scheme to the network.

5. Evaluations

The performance of the proposed schemes is to be compared with the well-known On Demand routing protocol: AODV (Ad hoc On demand Distance Vector). To accomplish this, an evaluation is currently being carried out by means of simulation using Network Simulator 2 (ns2) from Berkeley University. However, due to the complexity of the proposed schemes, many modifications have to be applied to the ns2 source codes. The results of the simulation are not yet available, but current findings suggest a positive outcome.

6. Conclusions

This paper has presented a new RREQ flooding control scheme named Pre-location Oriented Routing for the Ad Hoc On Demand routing protocols. This scheme uses the pre-location information to orient the RREQ flooding direction. It can effectively limit its route discovery query within a certain radius of the destination's previous location. Furthermore, Clustering Structure Routing is introduced to make the flooding mechanism more efficient and increase the route establishment speed.

Looking forward to the future, in order to make the network even more efficient, we should not only focus on the network layer (routing protocols), but also look at the MAC layer. Some information packets can be done by the MAC mechanisms. This may enable network to reduce a huge amount of information overheads.

References.

[1] Charles E. Perkins, lizabeth M. Belding-Royer and Nokia Research Centre, "Ad hoc On-Demand Distance Vector (AODV) Routing draft-ietf-manet-aodv-09.txt", Mobile Ad Hoc Networking Working Group INTERNET DRAFT 9 November 2001.

[2] Josh Broch David A. Maltz David B. Johnson Yih-Chun Hu and Jorjeta Jetcheva, "A Performance Comparison of Multi-HopWireless Ad Hoc Network Routing Protocols",

[3] Chen, B., Jamieson, K., Balakrishnan, H. and Morris, R, "Span: An energy-efficient coordination algorithm for topology maintenance in Ad Hoc wireless networks", In Proceedings of ACM/IEEE MOBICOM 2001, Rome, Italy, 2001.

[4] Taek Jin Kwon and Mario Gerla, "Efficient Flooding with Passive Clustering (PC) in Ad Hoc Networks"

[5] Aaron Fabbri, "Ad-Hoc Networks and Routing Protocols: An Overview", CIS 632, May 2000

[6] Theodore S. Rappaport. *Wireless Communications: Principles andPractice*. Prentice Hall, New Jersey, 1996.