Optimized Associativity-Based Threshold Routing for Mobile AdHoc Networks

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Abstract:

This paper proposes an Optimized Associativity-Based Threshold Routing (OABTR) protocol for ad hoc mobile networks with excessive traffic. An Associativity-based routing scheme is implemented, wherein a route is selected based on nodes having associativity-states that imply periods of spatial, temporal, connection and signal stability. The routes are selected based on their lifetime and hence there is no need to restart frequently, resulting in higher attainable throughput. This protocol is based on source-initiated on-demand routing. Here the multi-point relays are used to calculate the route towards any destination in the network. The protocol is particularly suitable to the large dense networks with high nodal mobility and topological changes. Multi-point relays are selected among the one hop neighbors with “symmetric" i.e. bi-directional link.

1.Introduction:

OABTR is designed for ad hoc mobile networks where mobile computers act as routers and packet forwarders in a wireless environment with no base stations. This protocol allows networks to be formed and deformed quickly, without users’ intervention and without the need for fixed network infrastructures. Unlike some existing link-state and distance vector-based approaches, OABTR does not attempt to consistently maintain routing information in every node. It is a source-initiated on-demand [1] routing protocol and it is based on the concept of longevity [3] of a route. Longevity of a route is indicated by associativity and it defines the spatial, temporal, connection and signal stability of mobile hosts. A route whose associativity [3] is closest to the threshold value is chosen.

OABTR is a compromise between broadcast and point-to-point routing and it uses the connection-oriented packet forwarding approach. OABTR only maintains routes for sources that actually desire routes. Routing decisions are performed at the destination mobile host (MH) and only the best route will be selected (based on QoS requirements) and used while all other possible routes remain passive, therefore avoiding packet duplicates.

The protocol exchanges topology information with other nodes of the network at regular intervals. To do efficient flooding of its control messages in the network, this protocol selects multi-point relays among the one hop neighbors with "symmetric" i.e. bi-directional link. Therefore, this automatically avoids the problems associated with data packet transfer on uni-directional links; like the problem of getting the ACKnowledgement for the data packets at each hop, which cannot be received if there is a uni-directional link in the selected route.

Section 2 elaborates on the motivation for the evolution of this algorithm. Section 3 explains the metric by which the longevity of a link is judged. In Section 4, the method to detect the status of links is discussed. In Section 5, Multipoint Relaying is discussed which minimizes the overhead of packet flooding. Section 6 explains the algorithm exhaustively, considering all the cases that may arise.

2. Motivation:

The existing Associativity Based Routing Algorithm considers a link between two mobile nodes to be stable if it exists for a long time, based on which the associativity ticks are calculated and the route with the maximum value, is chosen. This paper attempts to produce a greater hit rate by choosing an optimal threshold value, based on which the best route is chosen. Further more optimizations to reduce network traffic and duplication of packets have been introduced. Traditional routing algorithms, in stark contrast to the OABTR, would not satisfy the following requirements of an ad-hoc mobile network.

- Routing information need not be stored on each and every node.
- Routing needs to be done only on the request of the source or the sender who wants to transmit data.
- Routing information need not be constantly exchange. It is done only on a demand basis [1], thereby reducing network traffic which is an important parameter in mobile networks.

- Unlike the case of infrastructure networks, the links and the status of the Mobile Hosts is subject to change at random intervals without any visible regularity. Hence the choice of an optimal route should be a function of the link status.
- Packets should be sent only through bi-directional links, because acknowledgements can't be sent through unidirectional links. This will improve the reliability.

3. Property of Associativity:

The rule of Associativity [3] states that a MH's association with its neighbor changes as it is migrating and its transiting period can be identified by the associativity 'ticks'.

```
|<-Initial->|<----------stable---------->|<-dying->|
         ------------___________________-------------
                            |
                            |
                     Threshold value
                      --------------->
                          Time
```

fig 1: Life of a mobile route

As shown in fig 1, in an AdHoc mobile network initially there will be a period of instability. After that the route will be stable for some time during which the route can be used and then it will again become unstable (dying state), and the route cannot be used. Associativity ticks are updated by the MH's data-link layer protocol. A MH periodically relays beacons identifying it and constantly updates its associativity ticks in accordance with other MHs sighted in its neighborhood.

The associativity threshold [3] used to distinguish association stability and instability is a function of the beaconing interval, mobile host's migration speed and the size of the wireless cell. Associativity ticks are reset when the neighbors or the MH itself moves out of proximity, not when the communication session is completed and the route made invalid.

4. Link/Connection Status Sensing Packet Exchange Mechanism

OABTR uses a combination of BEACON and ECHO packets to ascertain connection (and indirectly link) status. On initialization, MHs would send a BEACON packet (once every

BEACON_PERIOD time units) to all its adjacencies to alert any adjacencies of the existence and identity of the broadcasting interface, which is its IP address. Reception of a BEACON at an interface implies either reconfirmation or creation of "IN" status of a connection at that interface, depending on whether or not the connection already exists, respectively. Once present, the status remains for MAX_BEACON_TIME (MBT) time units, at which time it times out if no subsequent BEACONs have been received; i.e. the link is declared DOWN and is removed from the data structures.

ECHO packets are used to respond to BEACONs, to let a "BEACONing" router know that someone hears its BEACON. An ECHO packet contains the identity of the interface broadcasting the ECHO and the identity of the BEACONing interface to which it is responding. Reception of an ECHO at an interface implies either reconfirmation or creation of "BIdirectional" status of a connection at that interface, depending on whether or not the connection already exists, respectively.

5. Multipoint Relaying

OABTR supports Multipoint Relaying (MR) -- a mechanism designed to minimize the overhead of packet flooding throughout a MANET by optimizing/reducing the number of duplicate retransmissions. In spite of the control overhead expenditures, MR has proven to be very efficient considering the high traffic found in the mobile ad - hoc network.

A Multipoint Relay (MPR) is a router, which is selected by a one-hop neighbor to forward or retransmit that neighbour’s packets. Every router has a set of nodes one hop away N1 (its one-hop neighbor set) and a set of nodes two hops away N2 (it’s two-hop neighbor set). The objective of a router participating in MR is to select a minimal subset M of MPRs from N1 so that their retransmissions cover N2.

Each MR router periodically broadcasts a Multipoint Relaying Advertisement (MRA) packet once every Multipoint Relaying Period (MRP) containing its Router ID (RID), the RIDs of all its one-hop neighbors in N1, and the subset M of these neighbors it has selected as its MPRs. This is an implicit broadcast to the current one-hop neighbor set N1. It can easily be seen that with each MR router transmitting the identity of its set N1, every MR router learns its set N2.

Algorithm used for Multipoint Relaying:

1. Start with an empty set M.

2. First select as MPRs those routers from F1 which provide the "only path" to reach some routers in N2.

3. While there still exist some routers in N2 that are not covered by M:

3.1 For each router in N1, calculate the number of routers in N2 reachable through this router, which are not yet covered by M;

3.2 Select as a MPR that router which reaches the maximum number of uncovered routers in R2.

6.Protocol Mechanism and Implementation:

To start with, when the network is initialized, each MH discovers its immediate neighbors with bi-directional links. This is a subset of all the nodes it is connected to.

- Now, the MH selects the Multi Point Relays using the multi point relaying algorithm described above. This is again a further subset of the nodes with bi-directional links.
- When a source wants to send a packet to its destination, a Route Request Packet is forwarded to its Multi Point Relays. Each of the intermediate MH's repeat the same operation until this packet reaches the destination.
- There needs to be a metric to decide on all the routes which resulted from the above operation. This is used to decide the optimal route.

i) Two threshold values are to be used. One for minimal threshold, which is used to select a particular link and other optimal threshold used to select a particular route at the destination.

ii) If a link's associativity ticks are less than minimal threshold then that route itself is discarded.

iii) The destination may receive one or more routes and select a particular route depending on which is closer to the optimal threshold.

iv) If no route is received by the destination then the minimal threshold is decreased and route discovery is done again.

v) A tie is broken within the optimal routes, based on the number of hops.

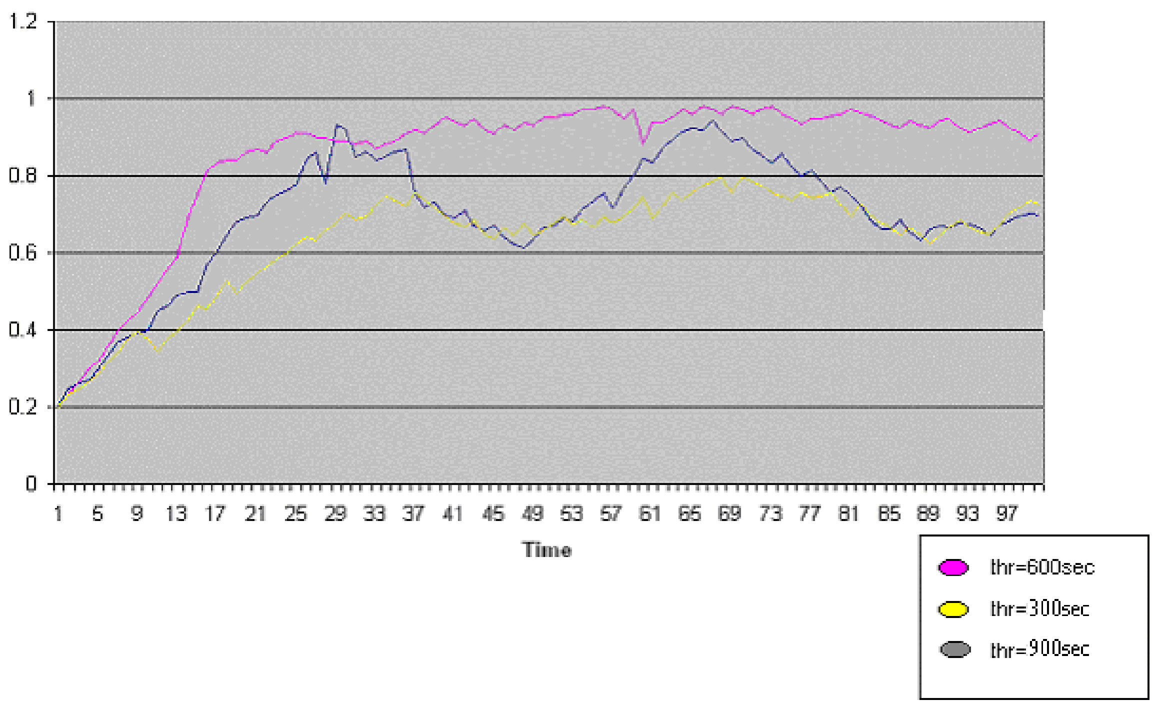
- This metric is the sum of the associativity ticks of all the links in each route. It makes use of a threshold value for the associativity tick, namely Associativity Tick Threshold (ATT). If the associativity tick value is less than the ATT, that route is discarded. If no route is selected, the ATT will be decreased progressively. If many routes qualify, the ATT will be increased progressively.

- The destination thus chooses the optimal route and sends a Route Reply Packet to the source and the source starts the transmission.

7. Performance:

A performance analysis [6] was carried out , based on some of the some of the routing parameters in AdHoc mobile networks.

a.) Reliability: The performance of this model was compared with the original associativity - based routing(ABR) protocol which chose the route with the maximum value for the associativity-ticks. In contrast, this OABTR protocol used an optimal threshold value and the route whose associativity-ticks value was closest to this, was chosen. This protocol was tested for certain threshold values varying from minimum to maximum (ABR) and a better hit-rate was produced with the optimal threshold value, which is evident from the following graph:-

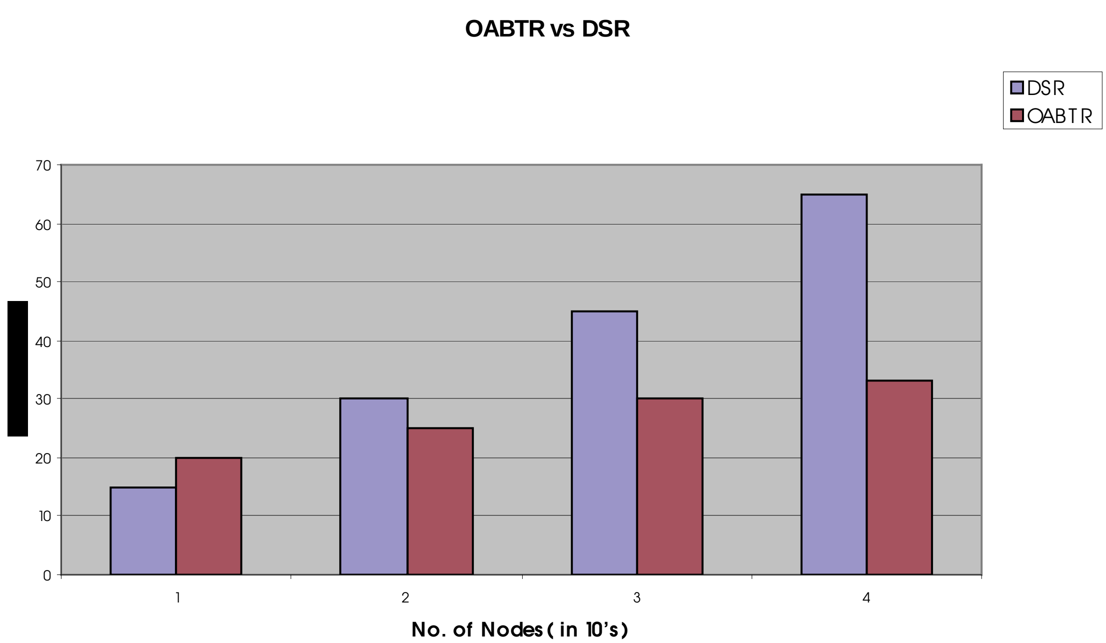


Y Axis: hit ratio i.e. the ratio of hits when the optimal route was chosen.

X Axis: time in minutes for which the behavior of the network was observed.

b.) Packet Transmission Time:

This model also reduced the average packet transmission time, due to narrowing down of the nodes, using the bi-directional links and multipoint-relaying concepts. This time was measured to be drastically lesser than that required in Dynamic Source Routing (DSR) Algorithm, which is one of the traditional routing algorithms used for mobile AdHoc networks. This can be observed from the following graph.



8.**Conclusion:**

Mobile routing algorithms are a proliferating field in today's ad-hoc mobile networks.This paper proposes an optimized routing algorithm for mobile networks.It concentrates on improving the performance of the network by increasing the packet-delivery rate, and reducing drastically the total packet- transmission time (including the time to transmit the Route-Request and Route-reply packets).In this protocol, the number of intermediate nodes transmitting the packets , is reduced by using the concepts of bi-directional links and multi-point relay, thereby bringing about a reduction in the packet -transmission time. By determining the best route, based on the longevity of the routes and the optimal threshold value for the associativity-ticks, the packet-delivery rate is increased.

This paper, though not a stand-alone solution to increase performance of ad-hoc mobile networks, however displays a comparison of OABTR protocol with already existing protocols like ABR and DSR with respect to performance issues in networks with heavy traffic, and thus confirms the supremacy of OABTR.

8. References:

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