A Hybrid Adaptive Routing Protocol for Ad Hoc Wireless Networks

K.Chaithanya
M.Tech (Digital Systems and
Computer Electronics)
JNT University Anantapur
Andhra Pradesh
ctaanya@yahoo.com
Sumalatha
Assistant Professor
JNT University
Anantapur Andhra Pradesh

Abstract **- Ad hoc networks are characterized by dynamic topologv caused by node mobility, multihop wireless connectivity and channel non-deterministic behavior (interference, multipath, hidden and exposed noden problem make the wireless channel veny difficult to *predict).* The behavior of ad hoc networks must be analyzed in detail as a result of the pairing of the selected MAC and Routing protocols. We focus our studies in the routing layer while closely observing the developments in MAC layer. We present and examine the characteristics of a new hybrid adaptive routing prolocol based on the ZRPprotocoL**

I. INTRODUCTION

In many environments, today, there is an increasing demand for wireless networking, allowing dynamic topologies and rapid deployment. This is due to the fact that in many cases robust deployment of a networking environment is required while mobility of the wireless nodes can be high. Ad hoc networks are self-organized wireless networks that are composed of mobile nodes.

They have no fixed infrastructure and they don’t require any setup procedure. Such networks are envisioned to have dynamic, sometimes rapidly-changing, random, multihop topologies which are likely composed of relatively bandwidth-constrained wireless links.

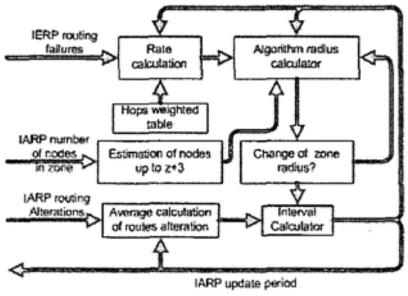


Figure 1. Architecture of AZRP

Classic examples of applications in environments with the above characteristics are law enforcement and emergency response in catastrophic events. A role for ad hoc networks exists also in construction sites, industry factories and public wireless networks in airports, stations, convention centers etc. Especially in industry factories ad hoc networks can play a very important role. The prospect of completely wireless connectivity inside an industry factory without the need of central management is also very appealing.

II. ADAPTIVE ZONE ROUTING PROTOCOL, AZRP

Due to the characteristics of reactive and proactive protocols as described in many papers, it is clear that there is no dominant routing approach covering all mobility cases encountered in wireless networks. In this paper we propose a hybrid routing protocol that can adapt to any given state of the network, using a unique approach in order to maximize efficiency and minimize packet **loss** and end-torend delay. **A** known protocol that uses a hybrid approach is ZRP (Zone Routing Protocol) *111.* We seek to enhance ZRP in order to be able lo adapt to any given state of the network, even in probable different network behaviors throughout the same network. The main purpose of the proposed algorithm is to use the information provided from the *IARP* (Intrazone Routing Ptotocol) and IERP (Interzone Routing Protocol) protocol in order to enhance the performance of ZRP with the use of variable zone radius for every node. The BRP (Bordercast Resolution protocol) provided by ZRP is much more effective if the zone is variable and reactive based on the mobility and traffic state of the network in the area around the node. Further information on IERP, IARP and BRP can be also be found in *111* and its references. Thus a variable zone can help to lower the excess traffic from IARP during **low** node mobility and packet traffic periods, by selecting a small zone radius. In high node mobility and packet traffic, AZRP will increase zone radius in order to provide a better knowledge in the network around the node and a clear way to and fiom a border node for the route acquisitiodresponse packet. By increasing the zone radius, the destination node may even be a new part of the zone. **As** the zone increases, reduced route acquisition times and lower bandwidth **loss** will result. The mechanism that decides whether to increase or decrease the zone radius in every node is shown in *Figure 1***.**

AZRP comprises of a standard IERP protocol like DSR or AODV and an IARP protocol like DSDV, *OSPF3* or OLSR. A typical topology for AZRP is shown in *Figure 2***.** The difference in our model is that it has a variable zone radius that is unique for every node and is controlled from the rate of packet *loss* in the vicinity of the node's zone as well as from the density and number of the nodes inside the zone. While the idea of variable zone has been mentioned in the past *121* with a different criteria for changing the zone radius and a global zone radius, we take a direct approach in making the virtual network topology to converge with the real network topology using whenever is needed more proactive or more reactive traffic. We propose a mechanism that can take in account the past rate of route failure in a T period of time and use a soft bounded area to decide whether to raise or decrease the radius by *1.* So if R(t) is the current zone radius, this is the next zone radius: R(t+T)=R(t) or R(t+T)=R(t)*l.

This decision is based on a calculated threshold of the reported route failure rate. Taking in account the number of nodes inside the zone, we estimate the number of nodes outside the zone up to ***3*** hops away and thus we have a prediction of upcoming route failure rate measured in *mute failures/node.* By comparison with the reported routing failures we determine if we experience excessive route failures or not, reacting by increasing or decreasing zone radius. The number of nodes up to ***3*** hops away of the zone boundaries is calculated based on the area of the zone and the area outside the zone up to ***3*** hops away:

$S_{zone}=\pi*(R_{zone}*Trange)^2$

$S_{zone+3}=\pi*[(R_{zone}+3)*Trange]^2-\pi*(R_{zone}*Trange)^2=(6*R_{zone}+9)*\pi*Trange^2$

So as a result $S_{zone}/S_{zone+3}=R_{zone}^2/(6R_{zone}+9)$. Because $N_{zone}=D*S_{zone}$ and $N_{zone+3}=D*S_{zone+3}$ and under the hypothesis that the node density D close to the zone boundaries is equal to the density inside the zone we can calculate the number of nodes outside the zone boundaries. Then $N_{zone}/N_{zone+3}=S_{zone}/S_{zone+3}$ and the number of nodes up to 3 hops away of the zone boundaries is: $N_{z+3}=\frac{6R_z+9}{R_z^2}*N_z$.

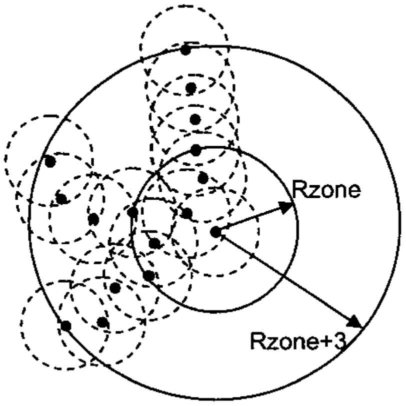


Figure 2. A typical topology for AZRP for Rz=3

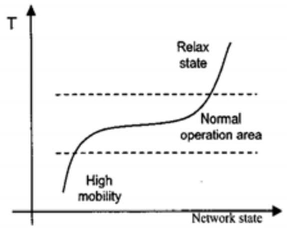


Figure 3. T variation depending on network state

The metric that is used in order to decide whether to change the radius or not is the rate of routing failures that the IERP protocol reports. We use a hop count distance from the central node of our zone in order to decide if the routing failures took place close to our zone's boundaries. In the table below it is shown that there is a hops weighted table which gives the weight of every routing failure reported by the IERP. The reason behind the selected **3** hops distance from the zone boundaries is based on two facts:

+ **A** metric is required from IERP that can be as much accurate as possible (larger distance means larger node sample).

+ The correlation between the node's zone and the nodes outside the zone kom which the metric occurs must be high. So we propose a logical number of ***3*** hops maximum distances, and after simulation we will readjust it if needed.

The above are summarized in the table below:

Failure in Rz+x hops away	Weight
x=1	4
x=2	2
x=3	1
x=4	0

It can be seen that the farther away we go from the zone boundaries the less weight we give to a route failure. Using this algorithm we minimize the impact in our zone radius from routing failures that take place far away. T is the interval between zone radius estimations, used also for the periodical updates IARF' does. We shall make this interval larger as the network shows low node mobility and low packet traffic, while in times of heavy traffic and high node mobility this interval will be relatively small in order to give us the opportunity to resize the zone effectively. In *Figure 3* we present the function that will be used in order to accomplish the above requirements.

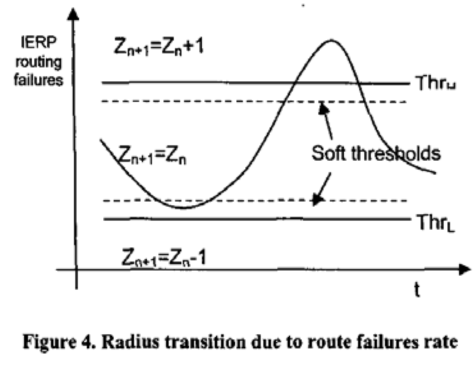


Figure 4. Radius transition due to route failures rate

It can be seen that there is an area of normal operation that T is between the two boundaries without a high variation. But when we have high mobility, T will be small and the network will react more effectively, while when the network is in a relax state, a much larger period of time will pass between two zone radius estimations. Mobility is something that we can't measure really, at least not directly, but we can get a very good estimation from the mobility pattems of the nodes inside the zone radius, since we already know the full topology inside the zone. So in order to measure node mobility, we shall track topology changes inside the zone and calculate a mean average of route alterations inside the zone. Of course the larger the zone grows, the more accurate our estimation of node mobility becomes.

We must point out the fact that the lower level of T is crucial to the convergence of the network and generally to the speed that the network will react in topology, node velocity and traffic pattem changes. It is clear that this lower threshold depends on the time that IARP can complete the discovery of the topology inside the zone. So Tmin>=$IARP_T$. In order to minimize this time we may have to develop a new algorithm for discovering the topology only R hops away, where R is the zone radius.

So using T as the timer interval between radius estimation, we can proceed in the main problem, the radius estimation algorithm which will be responsible for the zone radius of every node in the network In *Figure 4* we can see the mechanism that will decide whether to increase or decrease zone radius. It shows that if the IERF' routing failure varies between the two thresholds, no zone radius change will occur, meaning that the network is in a steady state. When entering the area between the soft and hard thresholds there is a 50% possibility that a zone radius change will occur. Only when crossing the ThrH and ThrL there will be a defmite radius change. When a zone radius change occurs there will be a fixed time until new zone radius estimation will take place, in order to give time to the node to find the IARP topology. The fact that each node maintains its own T and Rz makes this algorithm distributed not only in space but also in time. As a result not all nodes in the network will try to discover the topology inside their zone at the same time resulting in less burst traffic responsible for topology tracking. Of course triggered topology discovering can occur if a link is reported broken inside a node’s zone but that depends on the selected algorithm for IARP. Further enhancements can be achieved if we take in account the possibility that a node’s zone can be overlapped by another node’s zone. For example if node A has a zone radius of 2 and node B is I hop away and has a zone radius of 4 then all nodes included in node A’s zone are also a part of node B’s zone. In that case node A shall designate his zone to be zero and will cease any proactive route discovery until the overlapping zone decreases enough and B becomes a border node for *A*. Then it shall start again to maintain its own zone with a starling radius of 1.This scenario is shown in *Figure 5*. In case that this node is already a border gate for another node it will just retransmit the packet to its neighbours. The above characteristic will decrease the protocol overhead of proactive routing and will result in short-term dominant nodes that will act as routers for nodes with zone radius=O inside their zone. So in a typical network state, after a transitional period of time, there will be 3 kinds of nodes:

a. Standard Node, a node with Rzone>l that does not contain dead nodes. This is the typical ZRF’ node.
b. Prime Node, a node with Rzone>l that contains dead (non proactive) nodes. This node must keep a table of dead nodes in its zone in order to inform them about its zone radius value.
c. Dead Node, a node with Rzone=O that is contained in a Prime Nodes zone. It behaves exactly as a standard IARP node, with no proactive routing mechanism. It uses a reactive protocol to discover routes for its own generated traffic and just retransmits all other packets that it receives.

III. EVALUATION RESULTS

We present an evaluation of the above protocol against ZRP, DSR *[3]* and OLSR *[4]* in *Table 1*. Another very detailed evaluation of most routing protocols can be found in *[5]*. The evaluation is based on qualitative characteristics listed in *[6]*.

Hierarchical indicates whether some form of distinction between nodes exists. From this table it is depicted that only OLSR adopts a hierarchical structure which makes it a very good choice for large

scale networks. Update period denotes the time between successive routing information transmission and it is mainly applicable to proactive protocols. It is one of the most important attributes that can be configured. It can be easily seen that all of the known protocols can be configured to use a static value for this attribute. This results in non optimal performance in every possible network state. Most approaches until today try, mostly by using a simulation tool, to pinpoint a value of this attribute in order to achieve better overall network performance. AZRP takes a step forward and dynamically configures the above attribute in any protocol that will be chosen to act as IARP. In order to do that efficiently, as we have explained, it exploits information from IARP and IERP, evaluates the network state and alters “Update Period” accordingly.

It is obvious that only ***2*** of the protocols in **Table 1** may adapt in network status, OLSR and our proposal. OLSR needs further study in order to be able to adapt efficiently in network status changes. Furthermore, AZRP utilizes a changing period of update for IARP in order to minimize protocol overhead in low mobility and traffic. In high mobility and traffic, faster convergence can be achieved resulting in minimal route acquisition time. Whether the protocol is adaptive is shown in the filth column, while in the last two columns we present the information stored in every node and the type of routing used. By changing the zone radius, we minimize the overhead information

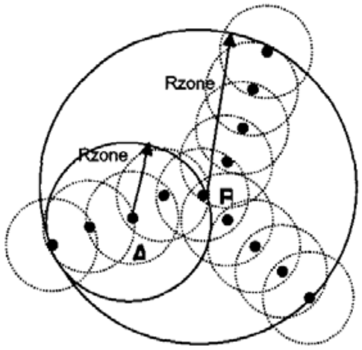
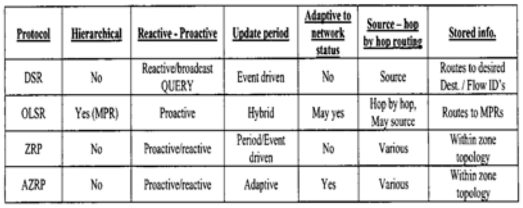


Figure 5. Fully overlapping zones of nodes A

Table 1: Evaluation of presented protocols



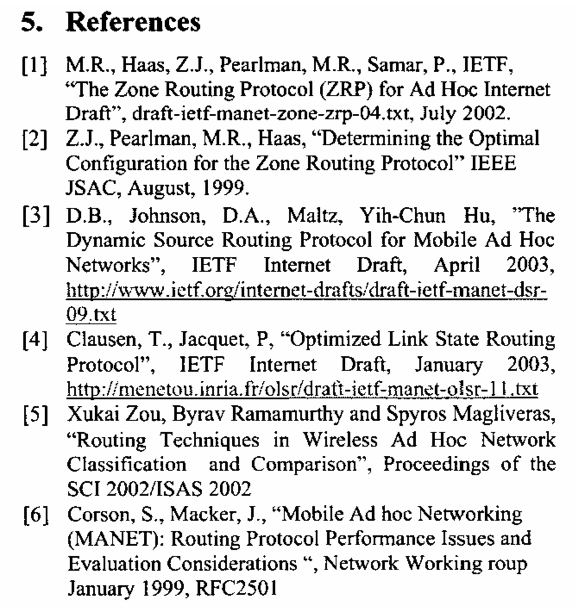
Protocol	Hierarchical	Reactive - Proactive	Update period	Adaptive to network status	Source – hop by hop routing	Stored info.
DSR	No	Reactive/broadcast QUERY	Event driven	No	Source	Routes to desired Dest. / Flow ID's
OLSR	Yes (MPR)	Proactive	Hybrid	May yes	Hop by hop, May source	Routes to MPRs
ZRP	No	Proactive/reactive	Period/Event driven	No	Various	Within zone topology
AZRP	No	Proactive/reactive	Adaptive	Yes	Various	Within zone topology

that is stored in every node, since if a node has none or very low mobility and/or packet traffic, it shrinks its zone and as a result less information is needed to he kept in memory.

Our plans include the development of a detailed model in OPNET MODELER lO.PL2 to test the behaviour of the above algorithm in various conditions as well as to determine the most suitable percentage of expected-to real route failure rate that is used to define Thr_H and Tbr_L. A performance comparison through simulation with today's most successful routing algorithms like DSR and OLSR will be our next step in order to evaluate our protocol.

CONCLUSIONS

We have introduced and presented in detail a new adaptive routing protocol named **AZRP,** an enhanced version of the known ZRP. An analysis of the algorithmic approach of **AZRP** has been carried out in order to depict and evaluate its advantages and pinpoint any possible problems. AZRP offers adaptive behavior via variable zone radius and controlled Update Interval of any proactive protocol acting as `IARP.` Thus we minimize protocol overhead, energy consumption and end-to-end delay in idle network state, while maintaining an aggressive and highly effective behaviour in high node mobility and data traffic.



5. References

[1] M.R., Haas, Z.J., Pearlman, M.R., Samar, P., IETF, "The Zone Routing Protocol (ZRP) for Ad Hoc Internet Draft", draft-ietf-manet-zone-zrp-04.txt, July 2002.

[2] Z.J., Pearlman, M.R., Haas, "Determining the Optimal Configuration for the Zone Routing Protocol" IEEE JSAC, August, 1999.

[3] D.B., Johnson, D.A., Maltz, Yih-Chun Hu, "The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks", IETF Internet Draft, April 2003, http://www.ietf.org/internet-drafts/draft-ietf-manet-dsr-09.txt

[4] Clausen, T., Jacquet, P, "Optimized Link State Routing Protocol", IETF Internet Draft, January 2003, http://menetou.inria.fr/olsr/draft-ietf-manet-olsr-11.txt

[5] Xukai Zou, Byrav Ramamurthy and Spyros Magliveras, "Routing Techniques in Wireless Ad Hoc Network Classification and Comparison", Proceedings of the SCI 2002/ISAS 2002

[6] Corson, S., Macker, J., "Mobile Ad hoc Networking (MANET): Routing Protocol Performance Issues and Evaluation Considerations ", Network Working roup January 1999, RFC2501