Evaluation and enhancement of ZRP performances

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Abstract— **ZRP (Zone Routing Protocol) is a hybrid routing protocol that combines proactive and reactive techniques. It distinguishes between two areas: proactive (or intra-zone) corresponding to the N-neighborhood in which it applies a proactive technique and reactive (or inter-zone) corresponding to the rest of the network (excluding the N-neighborhood), in which the reactive approach is applied. This hybrid protocol relates on of the fact that distant nodes communicate with each other less often than the neighboring nodes. Therefore it is more obvious to keep in the local topology only nodes at a reduced number of hops. A global knowledge of the entire network is generally expensive and less useful. We study in this paper the impact of the network size, the traffic load and the zone radius on ZRP performances. The obtained results show that a radius zone of 3 is a preferred and optimal value compared to radius 2 when the traffic load is important.**

Keywords : ZRP, Hybrid routing protocol, Proactive, Reactive, Traffic load, Zone radius.

I. INTRODUCTION

A wireless mobile Ad hoc network (MANET) is a collection of mobile nodes which are able to communicate each other without relying on pre-defined infrastructures. In these networks, each node participates in the provision of reliable operations in the network. Nodes may move continuously leading to a volatile network topology with interconnections between nodes that are often modified. As a consequence of this infrastructure less environment, each node communicates using its radio range with open transmission medium and some of them behave as routers to establish end-to-end connections. Due to these aspects and the fact that the resources are limited in mobile nodes, efficient routing in Ad hoc networks is a crucial and challenging problem. From these unique characteristics of Ad hoc networks, many requirements for routing protocol design are raised. There have been many proposals for routing protocols for Ad hoc networks [1], and several protocols have emerged. They can be classified into three main categories: the proactive such as OLSR [2], reactive such as AODV [3] and hybrid protocols such as the ZRP [4] protocol.

ZRP [4] is a hybrid protocol simple and efficient routing protocol allowing the network to be completely self-organizing and self-configuring without a heavy load in network.

Moreover, due to a previous study [5, 6] showing that hybrid routing protocols are better and suited for Ad hoc networks than proactive or reactive ones.

The rest of this paper is organized as follow: in Section 2, we give an overview of the concepts of the ZRP protocol. Section 3 relates some existing works and presents our contribution. A performance evaluation of the ZRP protocol is presented in section 4 using the simulator NS-2 [7]. Finally, a conclusion and some perspectives are given in Section 5.

II. ZONE ROUTING PROTOCOL (ZRP)

The routing protocol ZRP [4] is a hybrid between a proactive and reactive scheme. It is based on two procedures: the routing protocol intra-zone named IARP and inter-zone routing protocol, named IERP.

IARP is used only within the routing zone. This zone is defined for each node and has a size radius corresponding to a value of number of hops. For example, for a node, if this value is equal to "two" then all the nodes having a distance greater than two will belong to the zone of this node. Nodes at the perimeter of a given zone are referred to as peripheral nodes. IARP is usually implemented by various proactive protocols but this is not really specified, several proactive protocols may be used specially those based on the Shortest Path First (SPF-like) such as OLSR [2]. ZRP determines the distance that separates the node from the others in order to pre-define routes for the intra-zone. The content zone is known by the node but it has no information regarding other nodes outside the intra-zone. With this separation between intra-zone and inter-zone, Network topology changes or updates will have only a local impact and are not reflected globally in the entire the network. This considerably reduces the consumption of the network bandwidth.

IERP is responsible for establishing links with nodes in the inter-zone. It relies on bordercasting techniques (via BRP: Bordercast Resolution Protocol) which sends a packet to all peripheral nodes.

During the route request, the IERP first checks that the recipient isn't present in the intra-zone. If it's present then no connection process is necessary. Otherwise the source sends a "Route Request" to all

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peripheral nodes. The peripheral nodes, at reception of the message, will repeat the same operation. Each node receiving the request includes its identifier inside before forwarding it. This is called the process of accumulation routing. The peripheral node containing the destination in its routing zone replies, using its identifier in the query, by sending a "Route Reply" indicating the route. As a preferable "Route Request" is not broadcasted to a zone that has already been covered, IERP uses two mechanisms. The first kills messages that contain an identifier of a node in this intra-zone (except in the case of the previous node of course). The second is a complementary mechanism that records the identifier of the host in its list of quires only in the moment a "Route Request" to ignore a request already made before.

IERP also has a response mechanism resistant to errors. When the next hop route is identified as unreachable, a packet "Route Failure" is then sent to the source, warning and communications channel having expired are removed from the inter-zone routing table. IERP can be configured locally to repair the damaged route between zones with a procedure established route to the unreachable node.

Figure 1 shows the network components necessary for the implementation of the ZRP.

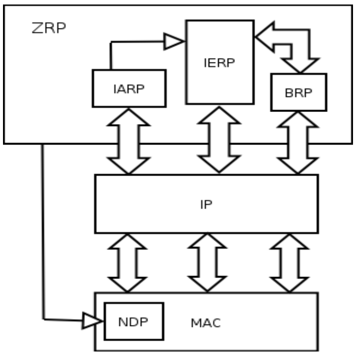

Figure 1. ZRP components.

With:

⟺ : Shows the exchange of packets between protocols in a both directions.

⟶ : Shows the passage of information between protocols in one direction.

IP : Internet Protocol

ICMP : Internet Control Message Protocol

IARP : Intra-zone Routing Protocol

IERP : Inter-zone Routing Protocol

BRP : Bordercast Resolution Protocol

NDP : Neighbor Discovery

An example of zone is shown in Figure 2. In this example, the zone radius equal to two and the routing zone of the node S is formed by all nodes that are around the node S with maximum of two hops. Therefore, all these nodes will be included in the zone routing.

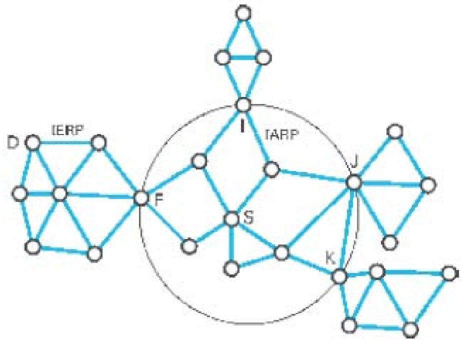

Figure 2. Example of zones.

III. Improving Zone Routing Protocol

A. Zone radius size

The value of the radius zone impacts the performance of the ZRP protocol. In general, mobile networks must set this variable to the smallest value possible, whereas for a fixed network, it will take a larger value. Similarly, in very active networks (frequent queries), the zone radius should be larger to contain node's mobility.

The values of this variable can be given as optimal and are determined according to certain criteria that impact the performance of the protocol. We try to find a compromise between the radius zone and the size of the routing table. This will be discussed in the next section.

B. Impact of Density, Traffic load and Mobility Model

In this paper, density is expressed by the number of nodes at a certain number of hops, traffic load and mobility models (Figure 3) are used as important parameters to determine the optimal zone radius. Some exiting researches [8] pointed out that the optimal value of the radius zone is two. They concluded that setting a higher zone radius results in little bordercast improvement and substantially increase the cost of zone maintenance, especially at higher network densities. Therefore, from this above observation they defined zone radius 2 as a base optimal zone radius. However, to find up most optimal zone radius, we derived the result from other work [9]. In this work, authors have conducted various experiments for IARP & IERP traffic with different zone radius and different node density. Analyzing the result given, they conclude that the zone radius 4 is the more suitable than other zone radius. The difference of the optimal zone radius between these is certainly due to others parameters of the simulations done. We think that the optimal zone routing radius is between 2 and 4. We want to study the radius optimality based on three parameters: traffic load, density and mobility models (Figure 3).

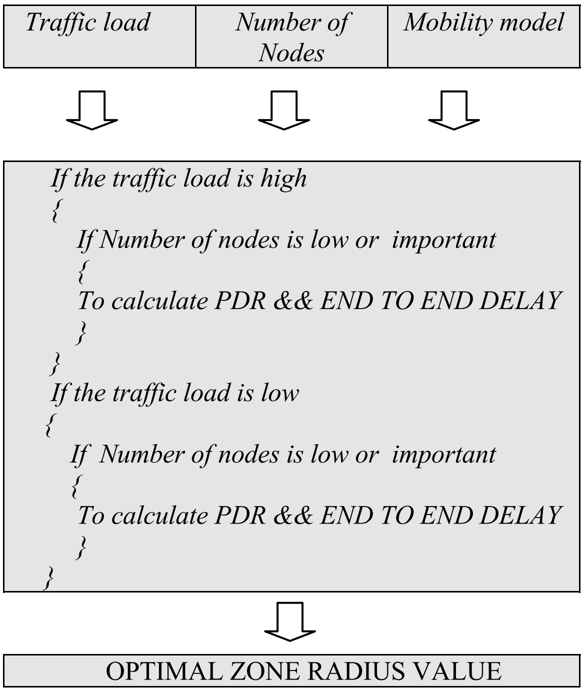

Figure 3. Optimal zone radius value.

C. *Mobility Models*

Currently there two classes of mobility models are available in the simulation of MANETs: based on traces or synthetic models. Trace models reproduce the mobility patterns based on the real life systems.

However; new network environments are not easily modeled, if traces have not yet been created. The synthetic model attempts to represent the realistic mobility behavior of the mobile nodes without the use of traces.

The synthetic mobility models for Ad-hoc network most commonly used are: Random Mobility Models Waypoint [10] "RWP", Random Direction [11] "RD", City Sections [12], Gauss-Markov model [13] and exponential correlated random, ECR [14].

We deal in this work in the first stage model of Random Waypoint RWP Mobility (Figure 4) with two input parameters (distance or time) and without pause. This model is used in many studies of Ad hoc network protocol. It is flexible, and it seems to create a realistic mobility model.

We subsequently integrate the mobility model of Random Direction (Figure 5) in the NS-2 simulator to study its impact on the performance of ZRP protocol. This is a little realistic model because it is not probable that the devices scattered randomly throughout the area with a pause only at the edge of a sector boundary. The modified Random Direction model allows nodes to pause and change direction before reaching the border area of simulation.

The third model is the integrated model City Sections [12] which models the movement of nodes (cars, trucks, people ...) in a city (Figure 6) which more suitable for VANETs.

In this model, the surface of simulation is modeled by a grid of streets (horizontal and vertical lines in a city, Figure 6). Instead of specifying a maximum speed in roads, it specifies a speed limit for roads. Each node begins the simulation at a predefined point, which is the intersection of two roads. The node randomly selects a destination, which is also the intersection of two roads, and began its trip to that destination by choosing the path that requires less time. On its arrival, the node chooses a new destination and repeats the same process, without taking a pause.

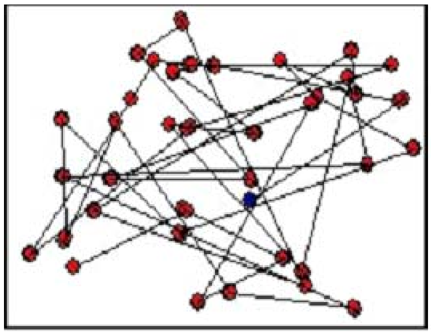

Figure 4. Random Mobility Models Waypoint.

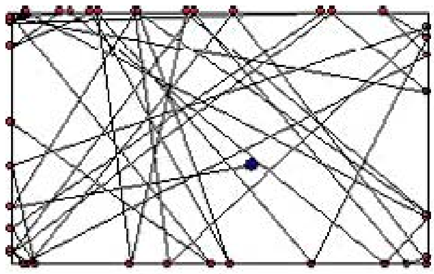

Figure 5. Random Direction Mobility Mode.

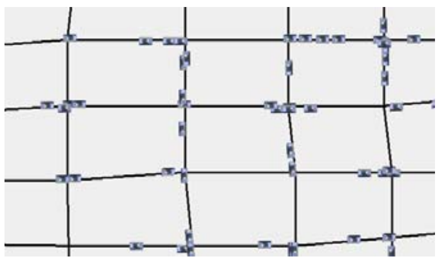

Figure 6. City Section Mobility Model

IV. SIMULATIONS AND PERFORMANCE EVALUATION

A. *Simulation Model*

To analyze the behavior of the routing protocol ZRP based on traffic load, density and mobility; we chose the NS-2 simulator [6] using traffic sources at a constant rate CBR (Constant Bit Rate) associated with the UDP protocol with different number of CBR sources.

We have experiment in this work the three widely mobility models: RWP [10], Random Direction RD [11] and City Section [12]. The first model is often used in performance analysis of routing protocols Ad hoc. The mobile nodes move in a square area of size 1500m x 300m. To describe the impact of density on the performance of routing protocols Ad hoc, we have varied the number of nodes between 10 and 100 nodes. The speed of nodes is uniformly distributed between 0 and 20m/s.

B. *Performance Criteria*

The objective of the experiments with the simulator NS-2 [7] is to analyze the performance metrics of ZRP, as the two following metrics:

- Packet Delivery Ratio is the ratio between the number of data packets received by destinations and the number of data emitted by sources.
- End to end delay: the time past between sending a packet by a sender and its receipt by the receiver.

C. *Simulation Results*

We present first results of study of the impact of traffic load. We varied the number of connections using 5, 10 and 20 connections for the RWP mobility model. For model Random Direction and City Section, we deal only load 20 connections just to check the impact of changing models on the performance of the protocol. The number of nodes is varied between 10 and 100 and without pause.

We use Rad 2, 3 and 4 and we have not been integrated Rad 5 because its results degraded compared to sizes (Rad 2, 3 or 4). The three figures (7.8 and 9) show that the Packet Delivery Ratio is influenced by the increased traffic load. In Figure 9, measures PDR are important to the zone radius 3 compared to other radius if the number of connections equal to 20. Otherwise, if the number of connections is equal to 5 or 10 (Figure 7 and 8), radius 2 is more suitable compared to other radius values.

We also note that the PDR is degraded if the number of nodes increased. This can be explained the increasing number of sending periodic Hello messages. A large number of Hello messages increases the probability of collisions and congestion especially at high density of nodes and high traffic load.

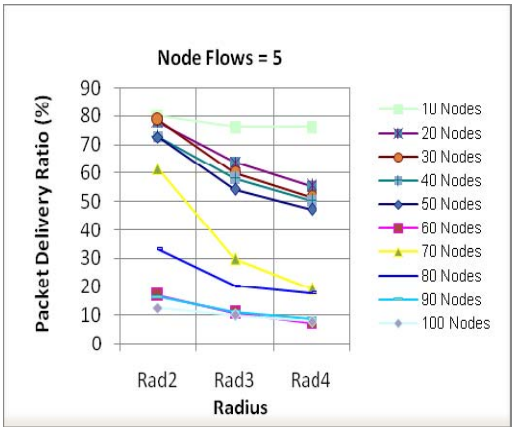

Figure 7. PDR vs. Radius for 5 flows.

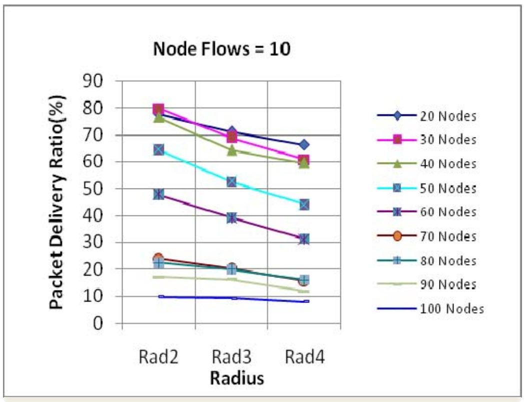

Figure 8. PDR vs. Radius for 10 flows.

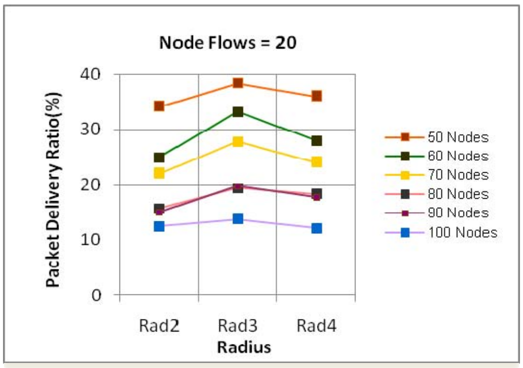

Figure 9. PDR vs. Radius for 20 flows.

Figure 10 shows that in terms of delay, the radius 4 is in order more effectively compared to radius 2 and 3. The Delay tends to decrease when the size radius increases. The proactive nature of ZRP protocol allows to quickly discovering the optimal route and subsequently the transmission time of packets of radius 4 takes less time compared to 2 or 3 radius.

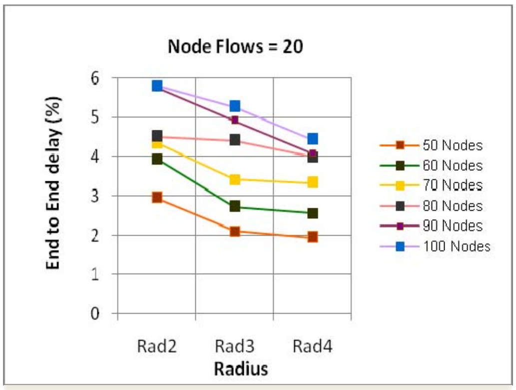

Figure 10. End to End Delay vs. Radius for 20 flows.

Measurements of the PDR (Figure11 and 12) shows that the PDR with radius 3 of both models of mobility gives interesting results compared to others radius. We note that this improvement remain even if we change the mobility model.

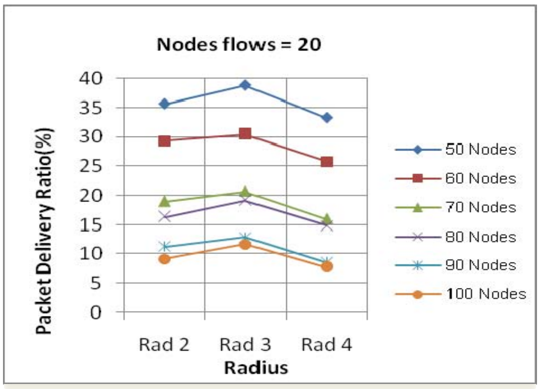

Figure 11. PDR vs. Radius for 20 flows of City Section.

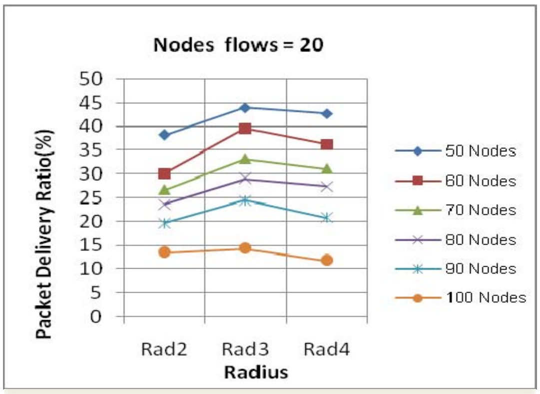

Figure 12. PDR vs. Radius for 20 flows of Random Direction.

These results explain the better performance for the zone radius 3 than 2 and 4 if the network traffic is important from a 20 connections generated in terms of Packet Delivery Ratio and Delay.

From this study we notice that if we have a mobile network with low density (less than 50 nodes) and whatever the Mobility Model used, the value of two for the radius zone seems to be optimal (see Table 1).

On the other side, if the mobile network has a medium or a high density (more than 50 nodes), important traffic load (from 20 connections) and with any mobility model, the value of three for the zone radius shows better results (see Table 1). This radius indicates that the size of proactive network is expanded to help establishing paths and connections in advance.

Optimal zone radius	Density	Traffic load	Mobility Models
Radius 2	+ *(Low)*	+ *(Low)*	*Any*
Radius 3	+++ *(High)*	+++ *(High)*	*Any*

Table 1. Optimal zone radius value versus environment network parameters.

V. Conclusion

In this work, we were interested on enhancing performances of the ZRP protocol. We have studied the impact of three parameters: density, load and mobility on the optimal radius value for ZRP. The obtained results show that a value of 2 can be considered as optimal for small and medium loads. The value of 3 is suitable in case of an important load and high density.

This work can be continued in many directions. We will try first to study the impact of the radius on other performance parameters (throughput and collisions). We also plan to investigate the integration of a metric of mobility, defined for the OLSR protocol [15], in ZRP. Another extension of this work can be done to study the possibility to have a dynamic radius. The radius will change its value depending on the change in the MANET.

References

[1] Carson, S. Scott , Macker and J. Joseph, "Mobile Ad hoc Networking (MANET) : Routing Protocol Performance Issues and Evaluation Considerations," RFC 2501, January 1999.

[2] T. Clausen and P. Jacquet. "Optimized Link State Routing Protocol (OLSR)," RFC3626, IETF MANET Working Group, 2003.

[3] C. Perkins, E. Belding-Royer and S. Das, "Ad hoc On-demand Distance Vector (AODV) routing," RFC 3561, Experimental, July 2003.

[4] Z. Haas, M. Pearlman and P. Samar, "The Zone Routing Protocol," Internet-Draft, draftietfmanetzonezrp04.txt, Work in Progress, July 2002.

[5] V. Ramasubramanian, Z. Haas, and E. Sirer, "SHARP: A Hybrid Adaptive Routing Protocol for Mobile Ad Hoc Networks," Proc. MOBIHOC Conf. 2003, pp. 303-314, June 2003.

[6] P.S. Kumar and S. Ramachandram, "Scalability of Network Size on Genetic Zone Routing Protocol for MANETs," icacte, pp.763-767, 2008 International Conference on Advanced Computer Theory and Engineering, 2008.

[7] The Network Simulator - NS-2, Information Sciences Institute - The University of Southern California.

Website: http://www.isi.edu/nsnam/ns/.

[8] Z. Haas and R. Barr, "Density-Independent, Scalable Search in Ad hoc Networks," Proceedings of IEEE International Symposium on Personal Indoor and Mobile Radio Communications, September 2005.

[9] M.R. Pearlman and Z. Haas, "Determining the Optimal Configuration for the Zone Routing Protocol," IEEE Journal on Selected Areas in Communications, Vol. 17, No. 8. pp 1395-1414, 1999.

[10] J. Yoon, M. Liu, and B. Noble, "Random Waypoint Considered Harmful", in Proceedings of the 22nd Annual Joint Conference of the IEEE Computer and Communications, Soc. (INFOCOM 2003), pp. 1312-1321, April 2003.

[11] C. Bettestetter, "Mobility Modeling in Wireless Networks: Categorization, Smooth Movement, Border Effects," ACM Mobile Computing and Communications Review, 5, 3, pp. 55-67, July 2001.

[12] A. Jardosh, M. Belding-Royer, C. Almeroth, and S. Suri, "Towards realistic mobility models for mobile Ad hoc networks," In Proceedings of the 9th Annual International Conference on Mobile Computing and Networking, pages 217.229, 2003.

[13] B. Liang and Z. Haas, "Predictive distance-based mobility management for PCS networks," in Proc. IEEE INFOCOM, New York, NY, pp. 1377-1384, Mars 1999.

[14] M. Bergamo et Al, "System design specification for mobile multimedia wireless network (MMWN) (draft) Technical report," DARPA project DAAB07-95-C-D156, October 1996.

[15] K. Oudidi, N. Enneya, A. Loutfi and M. El Koutbi, "Mobility and Routing OLSR, "9th African Conference on Research in computer Science, CARI08, Rabat, MAROCCO, October 2008.