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저자 (Authors)	Tung Thanh Le, Hai Nguyen Tien, Dong-Seong Kim
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Enhanced Zone Routing Protocol using Insect Behavior

Tung Thanh Le[1], Hai Nguyen Tien[2*], Dong-Seong Kim[3*]

[1)] Center for Advanced Computer Studies, University of Louisiana at Lafayette, LA 70504, USA. (E-mail: ttl8614@louisiana.edu)

[*)] Department of IT Convergence, School of Electronic Engineering, Kumoh National Institute of Technology, Gumi, South Korea. (E-mail: [2)] haint@kumoh.ac.kr , [3)] dskim@kumoh.ac.kr)

Abstract This paper proposes an enhanced zone radius determination algorithm with high efficient performance for nodes mobility in Mobile Ad Hoc Networks (MANETs) based on the foraging behavior of the bees to find an optimal route from their hives to the nectar sites. The proposed algorithm compares the zone radius of a node with adjacent neighbor nodes' ones to specify the optimal zone radius for adapting rapidly the network conditions instead of fine-tuning the radius of nodes one-hop by one-hop. The comparative simulation result shows the efficiency of our proposed algorithm in terms of computation time.

Keywords *zone radius, zone routing protocol, computation time, MANETs.*

1. INTRODUCTION

In MANETs, network conditions in the zone routing vary widely, therefore, Zone Routing Protocol (ZRP) requires to be dynamically reconfigured according to the local network conditions. The Independent Zone Routing Protocol (IZRP) framework was proposed to enhance the effectiveness of ZRP framework in the independent nodes [1]. The zone radius (r) determination algorithm in IZRP is based on a hybrid scheme that is combined between the min search scheme and the adaptive traffic estimation scheme. This hybrid scheme dynamically reconfigures the optimal zone radius of each node in a distributed fashion in the network. The min search scheme searches for the minimum routing control traffic by increasing or decrementing the routing zone radius of a node by one hope. The adaptive traffic estimation scheme tracks the optimal zone radius by fine-tuning the zone radius. This change is based on comparing the ratio of the reactive traffic to the proactive traffic of the zone radius ($\beta(r)$) with predetermined threshold (β_{thre}) in each of estimation interval. If $\beta(r)>\beta_{thre}$, r is increased by one hope to decrease the reactive traffic routing, otherwise is decreased to decrease the proactive traffic routing. However, this change in the zone radius after each of estimation interval can cause instability in the network. Additionally, IZRP algorithm is only incremented by one hop and hence it cannot determine an optimal zone radius immediately. This leads to the hysteresis in adapting to changes of the network characteristics, such as traffic and mobility patterns.

To resolve this problem, this paper proposes an enhanced zone radius determination algorithm that emulates the foraging behavior of the bees for nectar to specify the optimal zone radius quickly and to adapt rapidly the changes of network conditions, moreover, reduce control traffic overhead and computation time.

2. ENHANCED ZONE RADIUS DETERMINATION ALGORITHM

The proposed algorithm is essentially based on the bees' foraging behavior for finding good nectar [2][3][4], particularly, the foraging behavior of the onlooker bees which can determine appropriate values through comparing the previous nectar site with current one in their memory. If the quality of the previous nectar site is worse than one of the current nectar site, it will be substituted. The onlooker bees still continue this process until the termination criteria are met. From this idea, we applied to enhance the zone radius determination algorithm in MANETs. Our algorithm incorporates additional messages with the aim of tuning zone radius of adjacent nodes directly using the difference in their zone radii (Δr). Particularly, a node will compare its zone radius with one of the adjacent neighbor nodes in the neighborhood and then sends a message requesting the adjacent nodes to change directly the difference of zone radius, Δr. If the difference is either greater than or less than two, then the node sends an Increasing Radius Message (IRM) or a Decreasing Radius Message (DRM) requesting the adjacent node to increase or decrease its radius based on the difference.

In the IZRP algorithm [1], because node's zone radius is only increased or decreased one-hop by one-hop, the min search scheme cannot determine an optimal zone radius immediately. Additionally, even though the difference between zone radius of a node and one of its adjacent neighbor nodes is either greater than or less than two, the node's zone radius is only increased or decreased by one-hop until it meets the termination criteria. This drawback results in an enormous amount of control traffic in the routing zones and increases computation time as well. In the proposed algorithm, the computation time is primarily different from one of the IZRP algorithm at the min search scheme stage. Instead of fine-tuning the zone radii of the nodes one-hop by one-hop, the difference of zone radius, Δr, is adjusted directly through IRM and DRM messages if the difference is either greater than or less than two. This improvement in our proposed algorithm helps to reduce the computation time, control traffic overhead as well as prevent a low-latency scalability of zone radius which is the main cause of high control traffic overhead.

Let *I*, α_{IA_i}, α_{IE_j}, *Q(r)* denote the total control traffic corresponding to the number of hops of nodes' zone radii in the network, the proactive and reactive traffic component dominance in the total zone routing overhead and the current amount of IZRP traffic, respectively. The proposed algorithm is presents as follows:

The enhanced zone radius determination algorithm

Input: $I = Q(r)$; // total control traffic
Output: $r_{optimal}$ (optimal zone radius);
  for process *I* **do**
    if $Q(r)$!= $Q(r)_{previous}$ **then**
      Check the difference of node's zone radii Δr
      if $\Delta r = |r_i - r_j| < 2$ **then**
        Node *i* requests the adjacent nodes to change directly Δr through sending a message IRM
      else Node *i* requests the adjacent nodes to change directly Δr through sending a message DRM
      end if
    end if
    if $r_{current} < r_{optimal}$ **then**
      α_{IE_j} increases, α_{IA_i} decreases;
    else α_{IE_j} decreases, α_{IA_i} increases;
    end if
    Obtain $\beta(r) = \frac{\alpha_{IE_j}}{\alpha_{IA_i}}$
    if $\beta(r) > \beta_{thre}(r)$ **then**
      $r_{optimal} = r_{current}++$;
    else $r_{optimal} = r_{current}--$;
    end if
end for
Return: Min Search Scheme.

3. SIMULATION RESULTS

In this section, we evaluated the performance of our proposed algorithm based on comparing computation time of the two algorithms in terms of execution time in CPU with various total control traffic (number of inputs). The variation in the amount of IZRP traffic is based on the network medium, thus we assumed that a uniformly distributed function between (2000, 20000) to be input value of the total control traffic (*I*). The C programming language is used to evaluate the computation time for the two algorithms.

Figure 1 shows the dependence of the computation time on number of inputs. It illustrates that the computation time of the proposed algorithm is slightly lower than one of the original IZRP algorithm, nearly 8% with *I* = 2000. When *I* increased, this value increases from around 15% to 20% with *I* = 5000 and *I* = 20000, respectively. This considerable reduction of computation time demonstrates that the proposed algorithm enhanced the network convergence time and the hysteresis for nodes' adaptation in IZRP to the changes of network conditions.

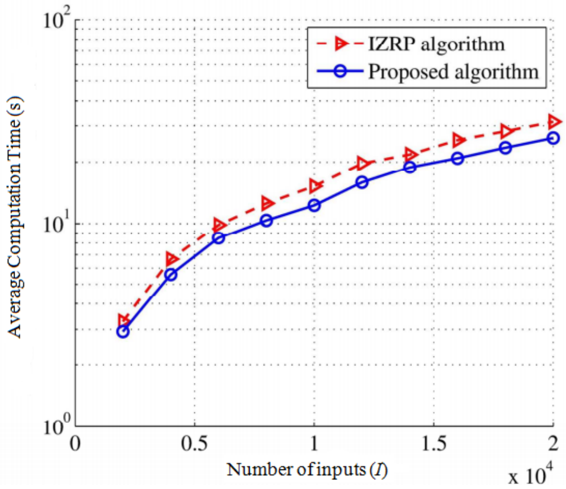

Figure 1. Comparative computation time results between the IZRP algorithm and the proposed algorithm

4. CONCLUSION AND FUTURE WORK

This work presents an enhanced zone radius algorithm based on bee's behavior with high efficient performance for nodes mobility in MANETs. Through comparing nodes' radii, a source node can rapidly determine its own optimal zone radius instead of fine-tuning the radius of nodes one-hop by one-hop. This enhancement reduces the computation time, control traffic overhead and adaptation hysteresis leading to adapt quickly to changes of the network conditions. Future works will address how to enhance the resilience of network in large scale wireless ad hoc networks.

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