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Bee-inspired Algorithm for Optimal Zone Radius in IZRP

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Abstract

본 논문에서는 최적화된 경로를 탐색하는 벌의 행동양식에 기반한 새로운 존 반경 설정 알고리즘을 제안한다. 제안된 최적 존 반경 설정 알고리즘은 능동 라우팅 프로토콜의 오버헤드를 줄이고 수동형 라우팅 프로토콜에서 통신 진로를 찾는데 필요한 지연시간을 줄인다. 독립적인 노드(IZRP)의 효율을 향상시키기 위해, 제안하는 알고리즘은 일반적인 존 반경 설정 기법 사용시 발생하는 제어 트래픽으로 인한 과부하 상황에서 인접 노드 사이의 서로 다른 존의 반경을 찾는데 사용된다. 모의실험을 통하여 처리량 향상, 제어 메시지의 오버헤드 감소에 관하여 제안된 라우팅 알고리즘이 가능함을 보였다.

Keywords - Zone radius; Independent Zone Routing Protocol (IZRP); Bee-inspired algorithm; Mobile ad-hoc networks (MANETs);

I. Introduction

The Zone Routing Protocol (ZRP) was known as a hybrid routing protocol, offers the advantage of scalability to adapt to a variety of network conditions. Typically, ZRP combines two phases, Proactive Routing and Reactive Routing [1][2][3]. Network conditions in the zone routing vary drastically; Hence, ZRP requires to be dynamically reconfigured with respect to the local network conditions. The Independent Zone Routing Protocol (IZRP) was proposed to enhance the efficiency of ZRP in the independently nodes [1][3][4]. In zone routing with independently sized routing zones, each node in the network can adaptively reconfigure its own optimal zone radius in a distributed fashion. The proportion of Proactive and Reactive Routing in this hybrid routing protocol can be fine-tuned by adjusting a single parameter - the Zone Radius of the node.

Typically, a zone radius (ρ) determination algorithm is based on a hybrid scheme that is a combination of the min search and adaptive traffic estimation schemes [1]. This hybrid scheme dynamically reconfigures the minimum zone radius of each node in a distributed fashion. In detailed explanation, the zone radius determination algorithm should be able to determine the optimal zone radius of each node in the network as well as should be adaptively quick to any changes in the network characteristics. The purpose of this algorithm is to make a minimal amount of extra overhead network by monitoring the control traffic passing via a node, and can fine-tune to adapt to regional.

In this paper, we propose a zone radius determination algorithm that emulates the characteristics of bees while foraging for nectar. Further, through a simulation, we demonstrate that the complexity of our proposed algorithm is lower than the previous algorithm in terms of IZRP zone radius determination. The rest of the paper is organized as follows. We issue the problem formulation and present our proposed algorithm in Section Ⅱ. Section Ⅲ expresses the simulations to demonstrate our algorithm. The conclusion and further work are represented in Section Ⅳ.

II. Problem Formulation

2.1 From insect behavior to network communication

The inspiration for the proposed algorithm was drawn from the nature-inspired artificial bee colony (ABC) algorithm that is a swarm-based meta-heuristic algorithm that was introduced by Karaboga [5][6][7]. In the ABC algorithm, three types of bees are considered: Employed bees E_b, Onlooker bees O_b and Scout bees. Typically, each cycle of the ABC algorithm is divided into three steps: (1) The employed bees are sent to possible nectar sites to measure the profitability (fitness values) of these nectar sites. (2) The onlooker bees receive this information, which is shared by the employed bees through a waggle dance [8]. (3) Scout bees are selected and sent to the nectar sites[8].

2.2 Zone radius determination algorithm

A zone radius determination algorithm for IZRP has been mentioned by Haas *et al.* in [1][3]. However, the min search scheme cannot determine a new optimal zone radius instantaneously because it is only incremented by one hop. In dense network scenarios, this drawback results in an enormous amount of control traffic in the routing zones [9].

To overcome the above-mentioned disadvantage, the proposed algorithm incorporates additional messages that fine-tune the ρ of adjacent nodes directly using the difference in their zone radii $\Delta\rho$ instead of overshooting one-hop in the min search scheme.

Our algorithm based on the onlooker bees O_b that can determine fitness values by comparing the current nectar site with the previous one in memory. The previous site is substituted with a new one if its quality is lower than that of the new one. Thus, O_b continue the process until the termination criteria are met. In the zone radius determination algorithm, a node can compare its radius with that of its adjacent nodes in its neighborhood and request the adjacent nodes to directly change $\Delta\rho$.

Algorithm 1: Zone Radius Determination in IZRP

procedure: IZRP ALGORITHM
Input: $n = Z(\rho)$;// total control traffic corresponding to the number of hops of nodes' zone radii in the network.
Output: Optimal Zone Radius $(\rho_{optimal})$;

for Process n **do**
  check the difference of nodes' zone radii $\Delta\rho$.
  if $Z(\rho) < Z_{previous}(\rho)$ **then**
    for Process $\rho_{current}$ with $\Delta\rho$ **do**
      $\rho_{current} = \rho{++}$;
    end for
  else
    for Process $\rho_{current}$ with $\Delta\rho$ **do**
      $\rho_{current} = \rho{--}$;
    end for
  end if
  if $\rho_{current} < \rho_{optimal}$ **then**
    I_{E_j} increases; I_{A_i} decreases;
  else
    I_{E_j} decreases; I_{A_i} increases;
  end if
  Obtain $\Gamma(\rho) = I_{E_j} / I_{A_i}$
  if $\Gamma(\rho) > \Gamma_{threshold}(\rho)$ **then**
    $\rho_{optimal} = \rho_{current}{++}$;
  else
    $\rho_{optimal} = \rho_{current}{--}$;
  end if
end for
Return: Min Search Scheme;
end procedure

If the difference in the zone radius of a node and that of its adjacent neighbor node is either greater than two or less than two, then the node immediately sends an up-radius message (URM) or a down-radius message (DRM) requesting the neighbor to scale up/down its radius on the basis of that difference (URM and DRM are the messages which demonstrate the number of hops in zone radii of nodes that need to be changed up or down respectively. I_{A_i} and I_{E_j} are the proactive and reactive traffic component dominance in the total zone routing overhead).

Algorithm 2: The proposed Zone Radius Determination algorithm for IZRP

procedure: PROPOSED ALGORITHM
Input: $n = Z(\rho)$;// total control traffic corresponding to the number of hops of nodes' zone radii in the network.
Output: Optimal Zone Radius $(\rho_{optimal})$;
for Process n **do**
  if $Z(\rho)! = Z(\rho)_{previous}$ **then**
    Check the difference of nodes's zone radii $\Delta\rho$;
    if $\Delta\rho = |\rho_i - \rho_j| < 2$ **then**
      node i requests the adjacent nodes to directly change $\Delta\rho$ by sending a message $URM(\Delta\rho)$;
    else
      node i requests the adjacent nodes to directly change $\Delta\rho$ by sending a message $DRM(\Delta\rho)$;
    end if
  end if
  if $\rho_{current} < \rho_{optimal}$ **then**
    I_{E_j} increases; I_{A_i} decreases;
  else
    I_{E_j} decreases; I_{A_i} increases;
  end if
  Obtain $\Gamma(\rho) = I_{E_j}/I_{A_i}$
  if $\Gamma(\rho) > \Gamma_{threshold}(\rho)$ **then**
    $\rho_{optimal} = \rho_{current}++$;
  else
    $\rho_{optimal} = \rho_{current}--$;
  end if
end for
Return: Min Search Scheme;
end procedure

Let $T_1(n)$ be the computing time of the IZRP algorithm (Algorithm 1) for input size n. Intuitively, we assumed that the time complexity for the initialization step is 1. During the simulation, n is incremented in sets of n iteratively; Thus, the time complexity in this step is $(1+n+(n-1))$. The variation in the amount of IZRP traffic is based on the network medium; Hence, we assumed a uniformly distributed function between $(2000, 20000)$ to set the input value of $Z(\rho)$, which is the current amount of IZRP traffic. The time complexity in this step is 1. Nodes rescale their zone radii on the basis of the amount of IZRP traffic; However, the rescaling is done in one-hop increments. Hence, even if the difference in the zone radii of a node and its adjacent neighbor is $\Delta\rho > 2$ or $\Delta\rho < 2$, the node is still only incremented by one hop until it meets the termination criteria. Thus, the time complexity in this step is $(1+n+(n-1))$ during the For loop and $(n-1)$ during the ρ one-hop increment/decrement. Next, the algorithm enters the adaptive traffic estimation scheme stage, which determines the optimal zone radius. The current zone radius is compared with a predetermined optimal zone radius and the proactive and reactive routing behavior of the network is adjusted. Altering the zone radius after this stage could lead to instability in the network if rapid adaptation is not performed. Finally, the computing time $T_1(n)$ is estimated as follows:

$$T_1(n) = 5n + 7. \tag{1}$$

On the other hand, let $T_2(n)$ be the computing time of the proposed algorithm (Algorithm 2). The time complexity of this algorithm is different from that of IZRP algorithm primarily in the min search scheme stage. Instead of fine-tuning the zone radii using one-hop increments, the difference in the zone radii $\Delta\rho$ in adjacent nodes is adjusted directly. Therefore, the computing time of the proposed algorithm $T_2(n)$ is:

$$T_2(n) = 2n + 6. \tag{2}$$

From Eq. 1 and 2, we observe that $T_2(n)$ is less than $T_1(n)$. Moreover, if looking at the overall traffic in the network, the proposed algorithm can drastically reduce the enormous amount of packet transmission in nodes.

Ⅲ. Algorithm Evaluation

In order to simulate node mobility in IZRP, we assumed all nodes to be connected. Based on the ***C*** programming language, Fig. 1 shows that the average computational complexity changing slightly at low number of inputs. The average computational complexity of our proposed algorithm is lower, nearly 10% at $n=2000$ than that of the IZRP algorithm. When n increases, this value increases to 20% and 23% at $n=10000$ and $n=20000$ respectively. Thus, when the zone radius of the node increases, the connection ratio probably decreases because of the large network connectivity and the unpredictability of node connectivity under various network conditions. However, our proposed algorithm remarkably enhanced the connection ratio and the hysteresis for adaptation in independent zone routing because of the reduction in the average computational complexity. Logically speaking, this proposed algorithm reduces control traffic overhead and improves throughputs and the ability to adapt by altering the optimal zone radius. Therefore, the proposed algorithm can prevent a low-latency scalability of zone radius, which is the main cause of high control traffic overhead and low throughput.

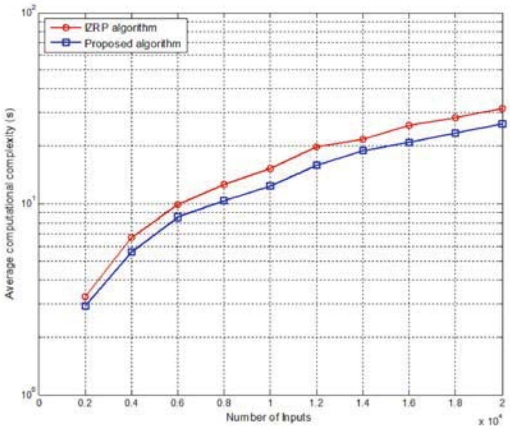

Fig. 1: Comparison the computational complexities between our algorithm and the default one of IZRP

IV. Conclusion

Due to the nodes mobility in the Mobile ad-hoc Networks (MANETs), it is hardly to manage the nodes' zone radii for Independent Zone Routing Protocol. Zone radius plays an important role among heterogeneous fashions in MANETs and ability to adapt the rapidly changing environmental conditions. Therefore, an optimized zone radius algorithm is also important in reduction of control traffic and improvement of throughput in the network mobility.

The paper has been discussed about the efficient zone radius determination algorithm with high efficient performance for nodes mobility in the MANETs. Based on the adjacent nodes' radii, a source node can estimate its own optimal zone radius. As in future work, we are implementing our proposed algorithm into IZRP completely in order to prove its performance being better than the current IZRP.

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