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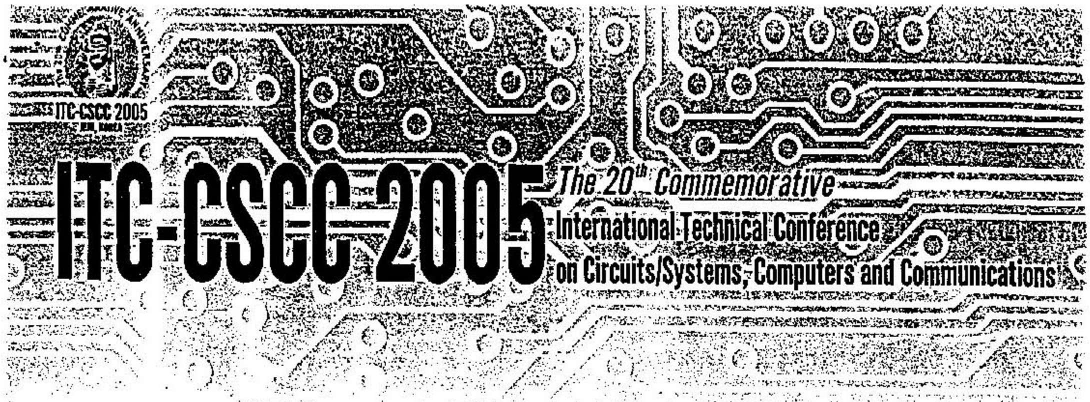
ผลงานวิจัยที่ได้รับการตีพิมพ์

1. Chotipat Pornavalai, Tosamon Littirut, “**A Combined Heuristic and Genetic Approach to the BGP Route Configuration Problem**”, ITC-CSCC, 2005.



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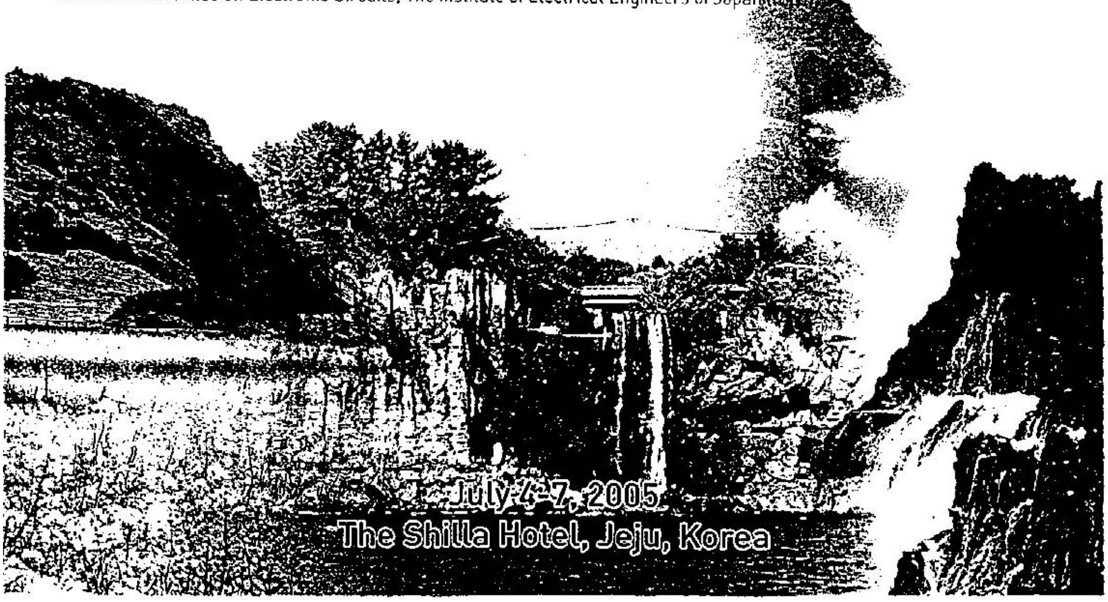

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A Combined Heuristic and Genetic Approach to the BGP Route Configuration Problem

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Abstract: In this paper, we proposed a combined Heuristic and Genetic Algorithm to determine BGP routes selection. The main objective is to discover feasible solutions that do not violate the bandwidth capacity of egress links and at the same time try to minimize solution cost The results from our simulation showed that our algorithm discovers more feasible solutions than existing algorithms especially when bandwidth capacity of egress links is low. Furthermore, it gives a little bit lower solution costs than any existing approaches.

1. Introduction

BGP [1] is an inter-Autonomous System routing protocol. An autonomous system is a network or group of networks under a common administration and with common routing policies.

The Single Egress Selection (SES) and Multiple Egress Selection (MES) problems are proved to be NP-Hard in [2]. One of the existing solutions for SES problem, known as SES Heuristic [2], is proposed based on linear programming (LP) relaxation with heuristic algorithm to round the fractional solution from LP to the nearby integers. Another solution known as MPPF_SES (Most Popular Prefix First) is proposed in [3]. Another solution is BTF (Biggest Traffic First) algorithm [3]. It chooses the egress point based on the volume of traffic, where the highest traffic volume is selected first.

This paper proposes a new and alternative solution to the SES problem. Our solution is based on the Genetic algorithm, where the crossover and mutation steps are combined with heuristic algorithm. We call our algorithm "Heuristic and Genetic Algorithm for SES" or (HGA_SES).

2. Genetic Algorithm for SES

The SES problem formation is based on [2] and [3]. The assumption of intra-domain links in local AS are infinity bandwidth but edge links that connect to other ASes are limited with less bandwidth capacities. Edge links functionality are transit traffic both direction. Links between ASes have high cost to the ISP, so we should utilize those edge links to the highest efficiency. The notation of variables are explained in [3]

Genetic algorithms have been used widely in searching and optimization, such as finding the maximum or minimum of a function over some domain space. In this paper, we applied the GA and heuristic to SES problem. The objective is to find the optimum solution cost, which it is the results of traffic volumes multiply with internal distance cost between ingress border router and egress border router. For BGP route selection, it will select the egress edge link for each destination prefix to transit the traffic which it has more than one to egress edge link in selection processes. But the constraint of SES problem is only one egress edge link selection for each destination prefix. Another constraint is every traffic volume must be able to be transited to each destination prefix. Finally, the capacity constraint ensures that the bandwidth requirement of traffic assigned to each edge link do not exceed its capacity.

3. Heuristic GA for SES

The Heuristic Genetic Algorithm for SES problem. It can improve the quality of the solution cost by using the heuristic crossover and mutation. The HGA_SES algorithm is shown in Figure 1.

```
HGA_SES Algorithm
1: generate chromosome by randomization.
2: GEN = 0
3: repeat
4:    compute fitness value of each chromosome
5:    select chromosome to mating pool
6:    Heuristic Crossover
7:    Heuristic Mutation
8:    New chromosome
9:    GEN = GEN + 1
10: until GEN < MAXGEN
11: end
```

Fig. 1 The HGA_SES algorithm

In Figure 1, the HGA_SES starts the first generation of chromosomes by randomization possible solutions without considering the solution cost, but constraints must be satisfied. Line 2 we initialize the generation variable (GEN). Next, a main loop of algorithm begins at line 3. Line 4, the chromosomes were computed the fitness value of each chromosome from Eq. (1). Line 5, it selects the chromosomes from mating pool based on fitness values. Line 6 and 7, the chromosomes were performed heuristic crossover and mutation. Line 8, the combination of results from crossovers, mutations and old chromosomes are the new chromosome for the next generation. Finally, it repeat line 3 to 10 until the generation numbers (GEN) are excess maximum generation numbers (MAXGEN) or all of chromosomes in the generation having the same cost.

4.1 Heuristic Crossover

The Heuristic crossover was modified from the SGA crossover which has the objective to find lower solution cost than parent chromosomes. It does not select a random prefix to do crossover but it tests to crossover all prefixes on the parent chromosomes. The position (prefix) on the chromosome that gives the lowest cost after doing all the crossovers will be selected as a child chromosome. See [4] for more detail.

4.2 Heuristic Mutation

The heuristic mutation is randomization of destination prefix to be mutated. After selected the prefix, it will check all egress edge links that able to transit traffic to destination prefix to find the solution cost for each egress edge link. Finally, it will select the lowest solution cost of checked egress edge link that satisfied capacity constraint.

5. Experimental Results

We set up network model for SES problem using the same parameters as same as [3]. For our GA parameters, the numbers of population was chosen to be 20. We also varied this parameter as well. But results showed that at population size of 20 gave good performance while the size is not big.

We generate different 100 network topologies and assume the capacities of edge links are equal. The egress edge capacities start at 100 to 500. We run each topology 100 times to find average solution cost.

We compared with our proposed HGA_SES algorithm with other known existing algorithms such as BTF (Biggest Traffic First) and MPPF (Most Popular Prefix First). Another existing algorithm which has not been compared in our simulation is called Rounding_SES [2] [3]. But simulation results from [3] already showed that MPPF can find much more feasible solution when capacity constraint is very strict than the Rounding_SES, though its cost is a little bit higher. However as stated in [3] that if an algorithm cannot send 100% of the offered traffic, it is in general not meaningful to compare solution cost.

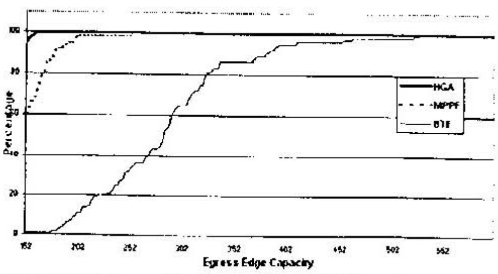

Fig. 2 Percentage of traffic sent in the SES environment

Figure 1 shows the percentage of total traffic that is successfully sent against the capacity of each egress link. If the result is 100%, it means that we can find all the traffic can be transited. The HGA found the 100% of feasible solution where the egress capacity is only at 162, while the MPPF and BTF are at 254 and 528 respectively. So our HGA gives 36% better performance when compared with MPPF.

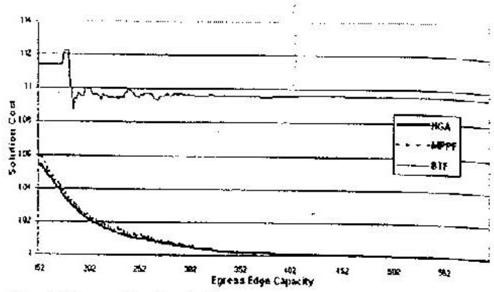

Fig. 2 Normalized solution cost in the SES environment

Another parameter to be compared is the total cost used by each algorithm which is shown Figure 2. The graph in Figure 2 is normalized with the total cost when edge link capacity has no effect to any algorithm. In 100 topologies were compared the solution cost. Some algorithm may be found or not found the solution cost. So we compare the solution cost when 3 algorithms can find it. In Figure 8, the HGA shows to have a little bit lower cost (0.01%) than the MPPF algorithm.

5. Conclusions

In this paper, we apply the GA with heuristic crossover and mutation to Single Egress Route Selection problem, which was proved to be a NP-hard problem. Results from the simulation shows that our algorithm able to find feasible solution greater than MPPF 36%. In future work, we will develop the GA with heuristic algorithm with MES problem.

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ประวัติผู้เขียน

นายทศมนต์ ฤทธิรุตม์ เกิดเมื่อวันที่ 29 พฤศจิกายน พ.ศ.2519 ที่จังหวัดกรุงเทพมหานคร สำเร็จการศึกษาปริญญาตรีบริหารธุรกิจบัณฑิต สาขาการตลาด จากภาควิชาบริหารธุรกิจ คณะวิทยาการจัดการ มหาวิทยาลัยสงขลานครินทร์ ในปีการศึกษา 2540 และเข้าศึกษาต่อในระดับปริญญาโท หลักสูตรวิทยาศาตรมหาบัณฑิต สาขาวิชาเทคโนโลยีสารสนเทศ คณะเทคโนโลยีสารสนเทศ สถาบันเทคโนโลยีพระจอมเกล้าเจ้าคุณทหารลาดกระบังในปีการศึกษา 2544 ส่วนด้านการทำงาน เริ่มทำงานเกี่ยวกับด้านคอมพิวเตอร์และงานพัฒนาระบบตั้งแต่ปี 2541 ถึง 2543 จากนั้นได้เปลี่ยนการทำงานมาในด้านระบบเครือข่ายคอมพิวเตอร์ตั้งแต่ปี 2544 ถึงปัจจุบัน โดยมีตำแหน่งเป็นผู้ให้คำปรึกษาด้านระบบเครือข่ายคอมพิวเตอร์