Graph optimization algorithm for low-latency indirect network

Masahiro Nakao
RIKEN R-CCS
Japan
masahiro.nakao@riken.jp

Masaki Tsukamoto
Kansai University
Japan
k046529@kansai-u.ac.jp

Yoshiko Hanada
Kansai University
Japan
hanada@kansai-u.ac.jp

Keiji Yamamoto
RIKEN R-CCS
Japan
keiji.yamamoto@riken.jp

1 INTRODUCTION

In a parallel computer system, it is expected to improve the performance of the whole system by introducing an indirect network with a small host-to-host average shortest path length (h-ASPL). To discuss such indirect networks in graph theory, the Order/Radix Problem (ORP) has been proposed[1]. The graph in ORP consists of three elements: the number of hosts (h), switches (s), and radix (r). ORP is defined as finding a graph with a minimum h-ASPL satisfying a given h and r. Note that s is arbitrary.

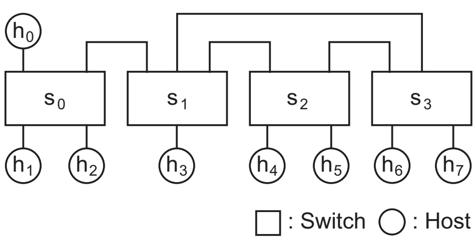


Figure 1: Example of graph $(h, s, r) = (8, 4, 4)$

Figure 1 is an example of the graph with $(h, s, r) = (8, 4, 4)$. A host is adjacent only to a switch, while a switch is adjacent to a host or other switches. The maximum total number of hosts and switches that can be adjacent to a switch is r. Thus, the graph represents the network topology of an indirect network consisting of hosts with one port and switching hubs with r ports.

This paper proposes an optimization algorithm for ORP based on Simulated Annealing (SA)[3]. The feature of the proposed algorithm is to improve the search performance of SA by giving symmetry to the graph.

2 OPTIMIZATION ALGORITHM

In this paper, we define a graph with symmetry as a graph such that, given any edge e of the graph, there is an automorphism [2] of the graph that maps e to $f(e)$. Figure 2 shows an example of a graph with $(h, s, r, g) = (12, 12, 4, 3)$ where the variable g is the number of symmetries. The possible values of g are the common divisors of h and s. For example, in the left of figure 2, the edge $0-6$ is mapped to the edges $4-10$ and $8-2$. The proposed algorithm performs a local search of SA with maintaining its symmetry. When exchanging edges, all symmetric edges are exchanged in figure 2.

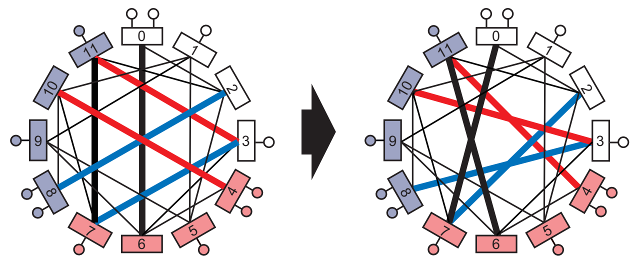
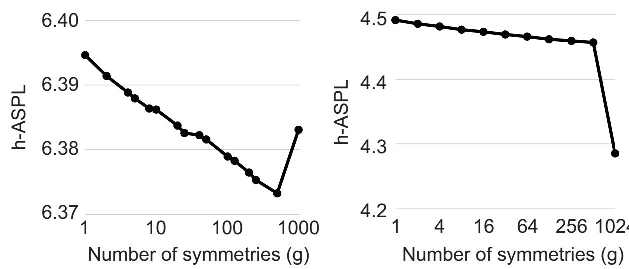


Figure 2: Example of graph and local search with symmetry



(a) (10000, 5000, 10) **(b) (65536, 3072, 64)**

Figure 3: Search performance with symmetry (h, s, r)

3 RESULTS

We investigate the relationship between the value of g and search performance of the proposed algorithm using $(h, s, r) = (10000, 5000, 10)$ and $(65536, 3072, 64)$. Figure 3 shows that the larger g is, the smaller h-ASPL of the graphs can be found. However, Figure 3-(a) also shows that the h-ASPL is worse when g is too large. The value of g indicates the strength of the regularity of the graph. The [1] describes that h-ASPL is smaller in randomly-optimized topologies than in regular ones (e.g. Torus topology). From these, we can say that the h-ASPL of graphs with a good balance between regularity and randomness is small.

REFERENCES

[1] R. Yasudo et al. 2019. Designing High-Performance Interconnection Networks with Host-Switch Graphs. *IEEE Transactions on Parallel and Distributed Systems* 30, 2 (2019), 315–330. https://doi.org/10.1109/TPDS.2018.2864286
[2] C. Godsil and G. Royle. 2001. *Algebraic Graph Theory*. Graduate Texts in Mathematics., Vol. 207. volume 207 of Graduate Texts in Mathematics. Springer.
[3] S. Kirkpatrick et al. 1983. Optimization by Simulated Annealing. *Science* 220, 4598 (1983), 671–680.