Development of Graph Library and Optimization Algorithm for Order/Degree Problem



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What is Order/Degree Problem ?

Background

- Network in distributed memory system is required to increase its scale and reduce its latency
- A good network topology has a small number of hops between nodes
- When connecting nodes randomly, the number of hops shrinks due to the small world effect, and its latency decreases [Koibuchi2013]



(It takes a long time for the message to arrive)

Randomized Topology (Shortcut allows a message to arrive soon)

Definition of Order/Degree Problem

The network topology of distributed memory system can be represented as an undirected graph by regarding its nodes as vertices and its network cables as edges.

The Order/Degree Problem involves finding a graph with the minimum diameter and ASPL (Average Shortest Path Length) from a set of undirected graphs that satisfy a given number of nodes n and degree d.

Graph Golf Competition

Find each graph with the smallest diameter and ASPL in some problems with different n and d combinations (Problems are changed every year).



http://research.nii.ac.jp/graphgolf/



Approach

Make the network topology symmetrical

Our algorithm uses Simulated Annealing (SA), its search performance is improved due to reduce search space



You can download our optimization algorithms and graph libraries in https://github.com/mnakao/ODP

Calculation time on Cygnus

	Time (sec.)	Processor
] \	3779.38	1 CPU core
1 1	474.53	12 CPU cores
]]	28.71	1 GPU
▲	0.28	128 GPUs

Fime for calculating ASPL in the graph with (n, d) = (1000000, 32)

13,500 times faster !!





(2) Select edges symmetrically related to the edges selected in (1) (3) Apply the 2-opt method to the edges selected in (1) (4) Apply the 2-opt method to the edges

selected in (2) in the same way as (3)

Evaluation

- In vertical axis, ASPL Gap is a difference from ASPL of a graph and its theoretical lower bound
- Search performance tends to increase as the number of symmetries increases





We won the award of **Graph Golf Competition 2021**