



# International Competition on Graph Counting Algorithms 2024 – Overview and Results –

Takeru Inoue (NTT) with ICGCA Organizers

## Graph counting problem

- Counting # of subgraphs on a graph under constraints
- #P-complete, # of subgraphs can be exponential with graph size

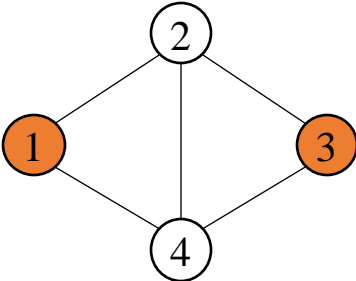
## Algorithms

- Developed to work for graphs with hundreds of edges
- Found many applications e.g. infrastructure networks

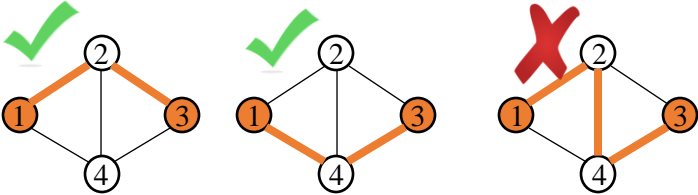
# Problem and tracks

## Problem

- Given graph, vertex pair, and max path length
- To count paths between the pair under length constraint



Max path length: 2



2 paths

## Four tracks

$$\left[ \begin{array}{l} \text{Undirected graphs,} \\ \text{Directed graphs} \end{array} \right] \times \left[ \begin{array}{l} \text{Single thread,} \\ \text{Multi threads} \end{array} \right]$$

# Scoring criteria

## Grand winner

- Solved *most* benchmarks correctly
- 100 benchmarks per track
- 10 min / benchmark



## Winner for ideas

- Evaluated by *ideas* written in papers
- Determined by mutual voting among participants



# Evaluation environment

Solvers were evaluated on *organizers'* computer

- 12 CPU cores and 64 GB memory
  - › 4 performance cores and 8 efficiency cores
- Ubuntu Server 22.04 LTS



Intel NUC 12 Pro Kit NUC12WSHi7

ICGCA allows

- *Parallel* solvers using multiple CPU cores for multi-thread tracks
- *Portfolio* solvers implementing multiple algorithms for all tracks

# Benchmark set

Benchmark set consists of

- Public and private instances
- Organizer and contestant-submitted instances
- Only real graphs except submitted ones
  - › Origins are written in instance files

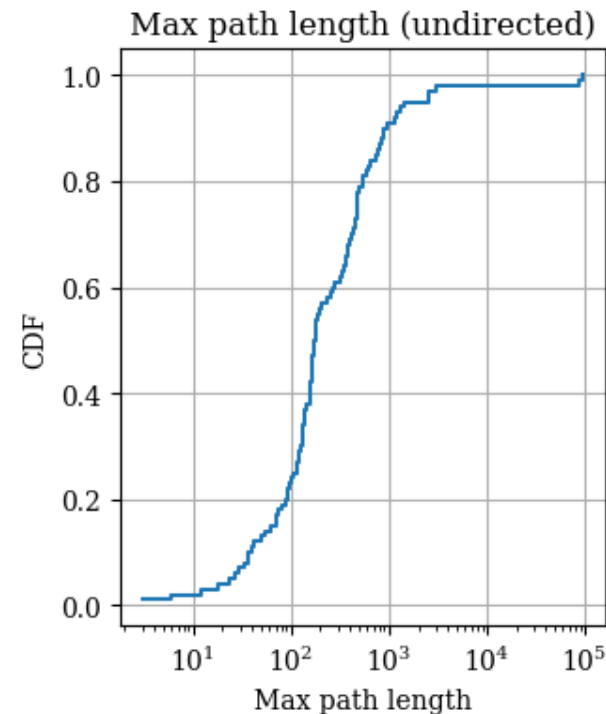
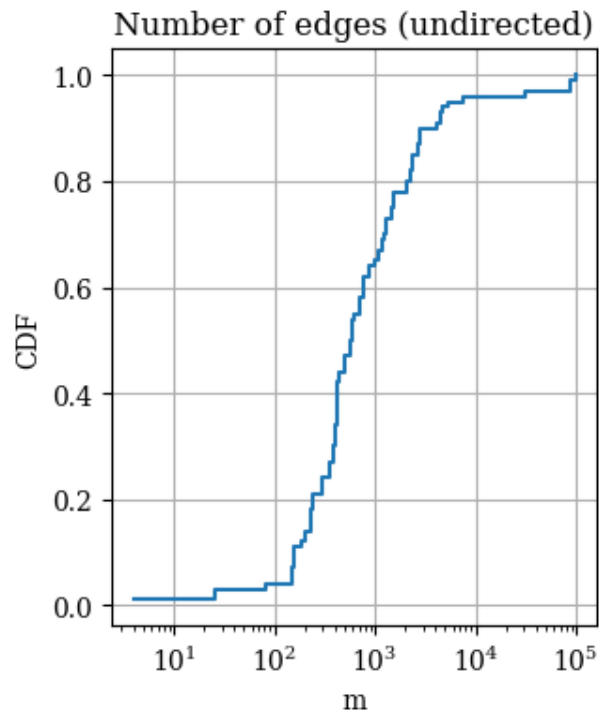
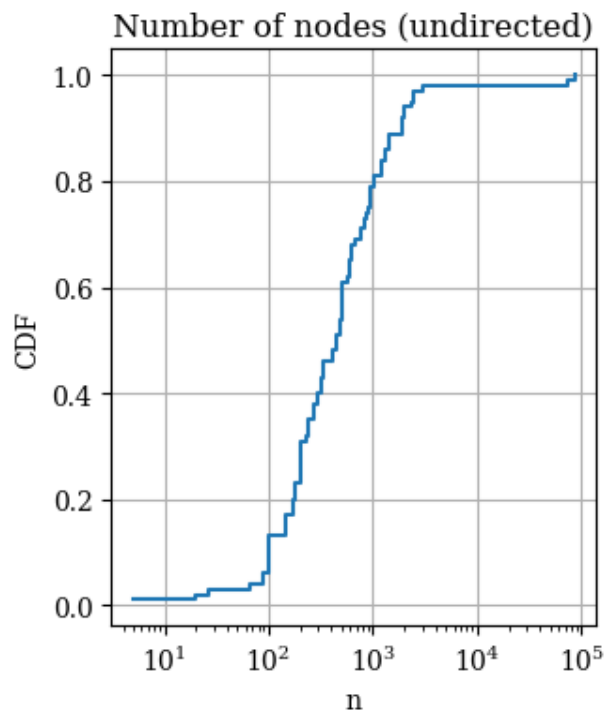
	<b>Undirected</b>	<b>Directed</b>
<b>Public</b>	50	50
<b>Private</b>	50 (9 are submitted)	50 (8 are submitted)

# Why submit benchmarks?



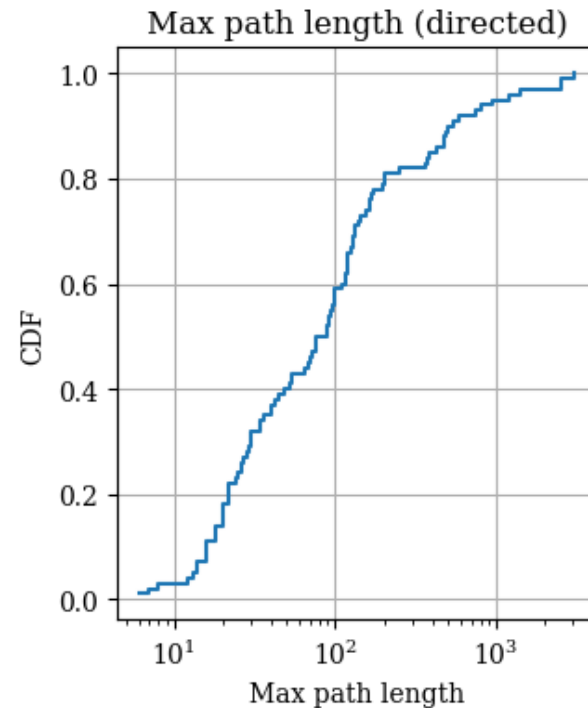
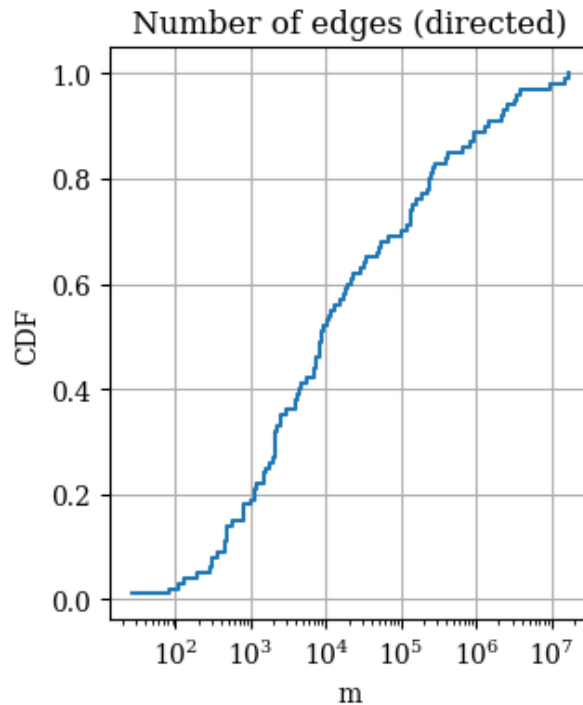
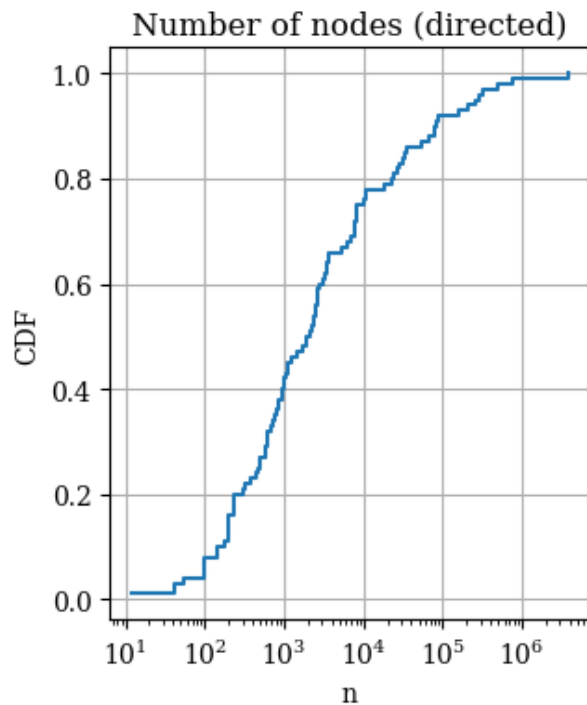
- To increase benchmark diversity, we invited contestants to optionally submit benchmarks
  - Similar practices in competitions like SAT have successfully expanded benchmark collections
- Submitted benchmarks were used as private benchmarks
  - For undirected tracks, 9 benchmarks were submitted by 2 teams
  - For directed tracks, 8 benchmarks were submitted by 1 team
  - Most submissions came from the grand winner, who will discuss their intent behind creating these benchmarks in their winner's talk
- Benchmark submissions also carry a strategic aspect in the competition
  - Participants were free to submit unique benchmarks they know how to solve, potentially giving them a competitive edge

# Undirected benchmarks

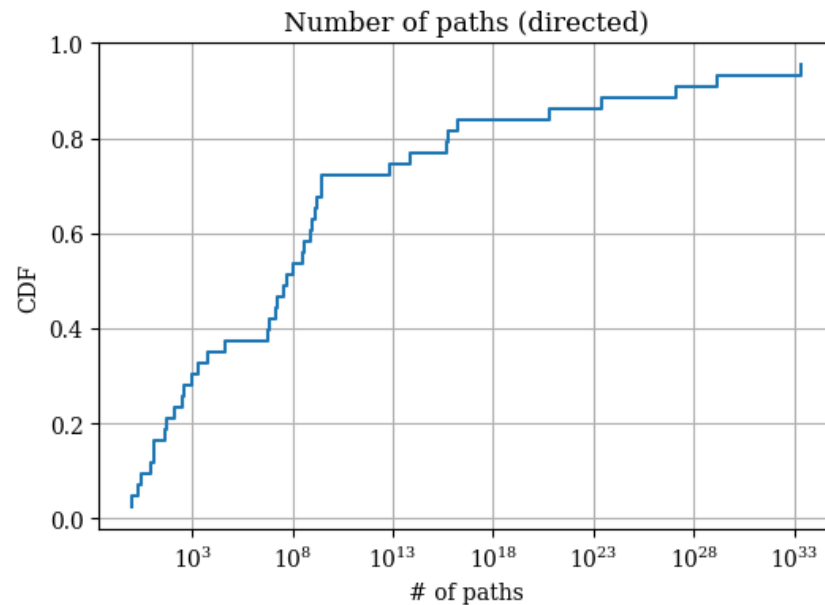
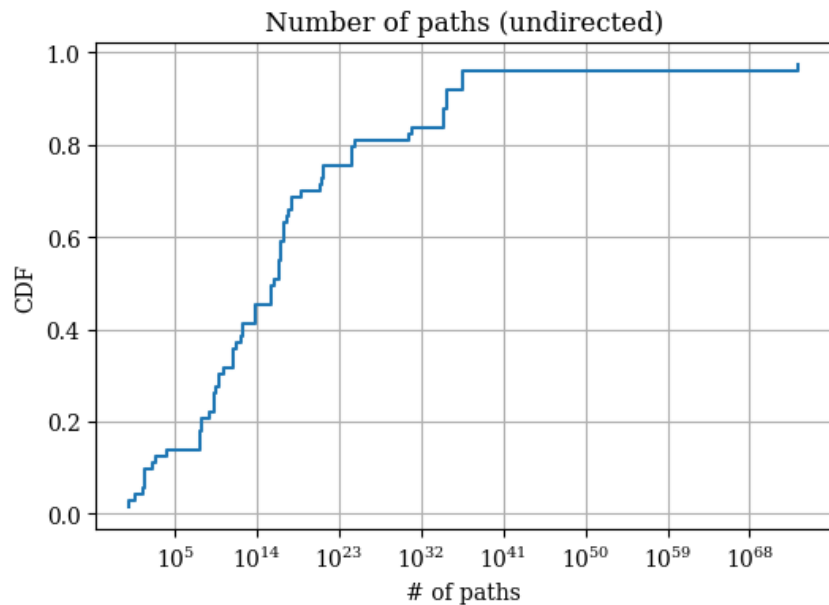




# Directed benchmarks



# # paths for solved benchmarks

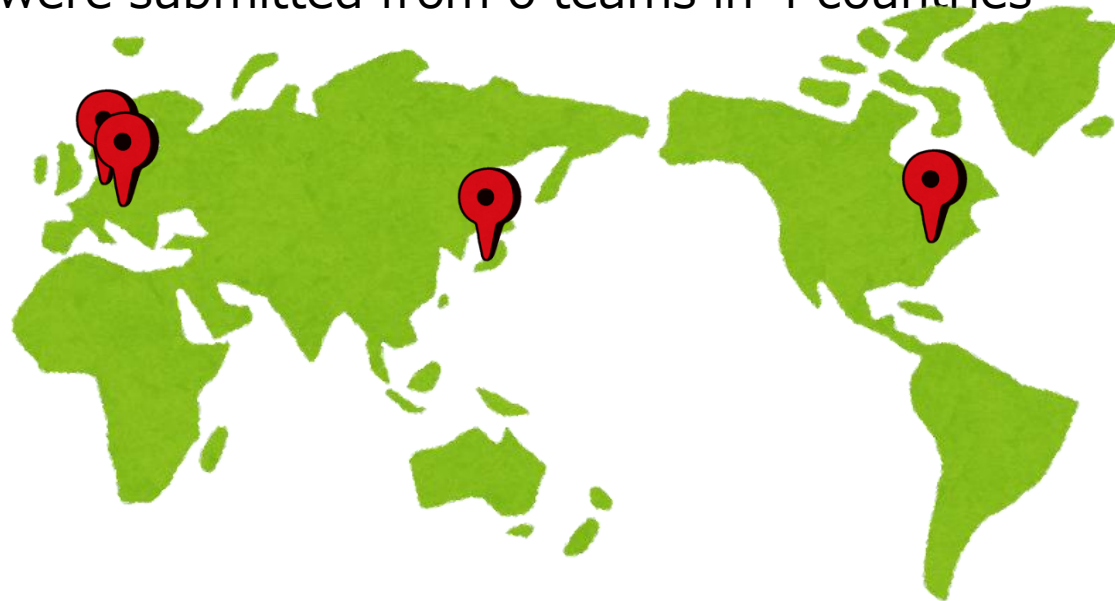


# Timeline

ICGCA website was opened in March 2024

Solver submission due was September 24

- 18 solvers were submitted from 6 teams in 4 countries





Idea award



Grand winner

Award ceremony will take place after my talk



# KAG-TeamS

Undirected/multi-thread solver

Keita Maeda, Ryuma Noma, Toshiki Saitoh,  
Takumi Shiota, Shinryu Tachibana,  
Naoya Taguchi, and Soma Takao  
(Kyushu Institute of Technology)

**Received 52/22% of votes for team/solver**

**Grand winner**



**TL;DC**  
Too Long Didn't Count



Rafael Kiesel (Vienna University of Technology)  
and  
Markus Hecher (Massachusetts Institute of Technology)

**Won all four tracks!**

# # solved benchmarks

Abbreviations:

- **U**ndirected
- **D**irected
- **S**ingle thread
- **M**ulti threads

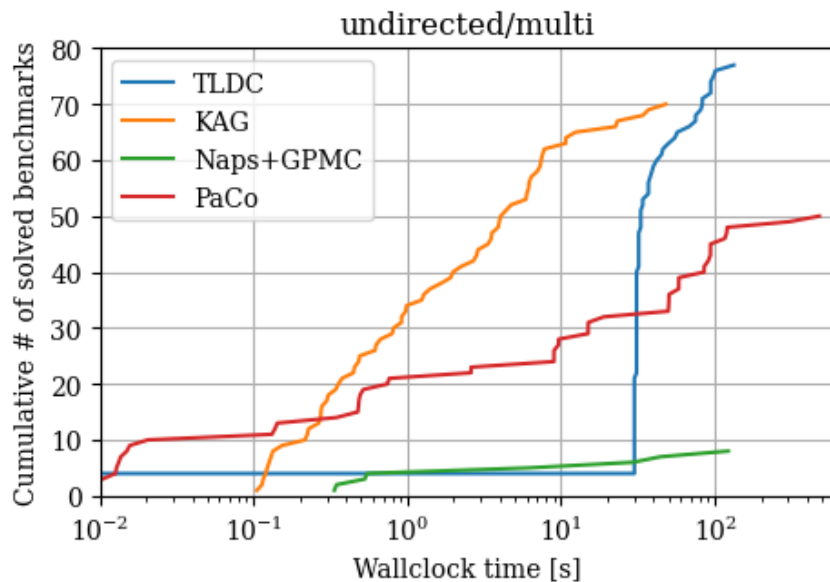
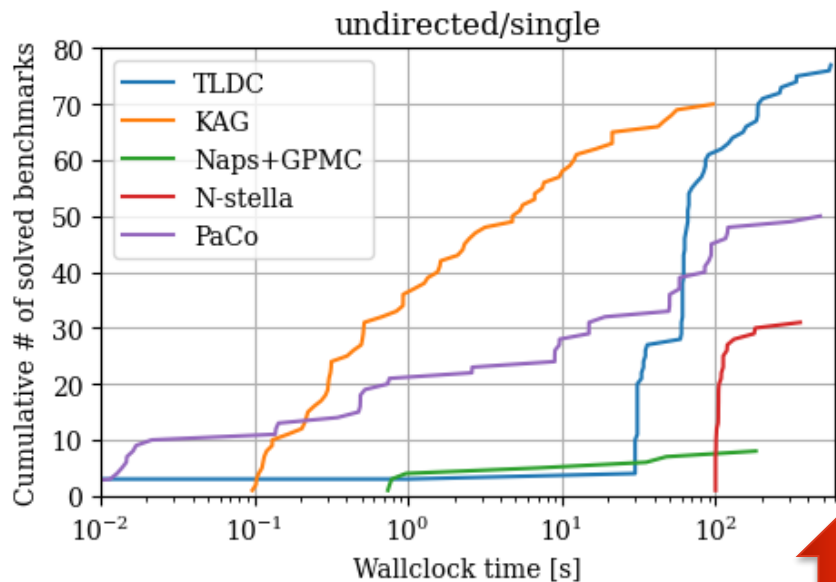


	U/S	U/M	D/S	D/M
<b>TL;DC</b>	77	77	52	53
<b>KAG</b>	70	70	41	40
<b>PaCo</b>	50	50	36	36
<b>N-stella</b>	31			
<b>NaPS+GPMC</b>	8	8	7	8
<b>XCC</b>	7			

# # solved benchmarks vs runtime: undirected

Time budget:  
10 min / benchmark

Multi-threading reduced  
computation time, but had little  
impact on # of solved benchmarks



Final results

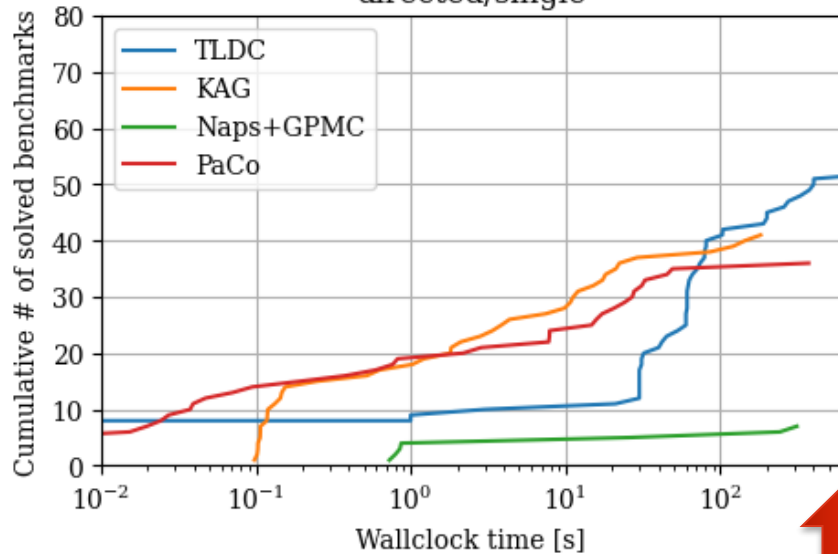


# # solved benchmarks vs runtime: directed

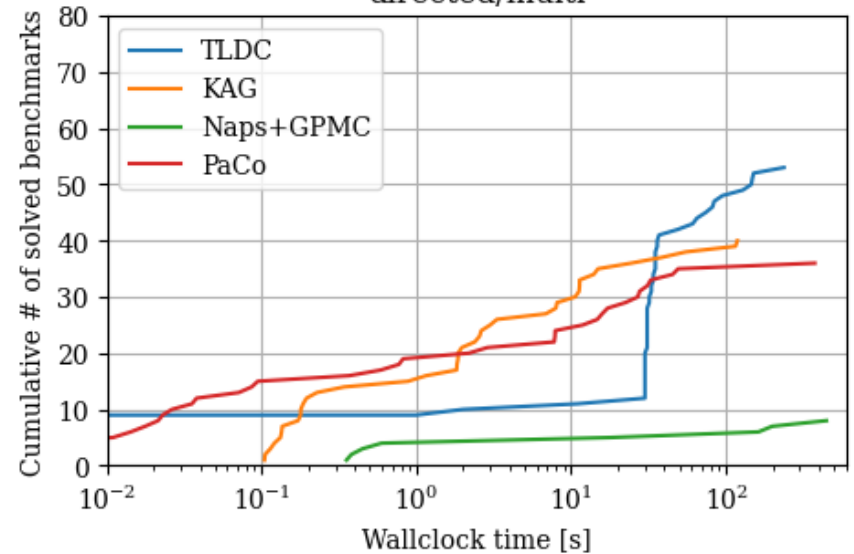
Time budget:  
10 min / benchmark

Multi-threading reduced  
computation time, but had little  
impact on # of solved benchmarks

directed/single



directed/multi



Final results

Thanks to everyone, ICGCA 2024 is concluding successfully

- We used 200 challenging benchmarks, including 17 submitted by contestants
- Grand winner solved 129 of these 200 benchmarks in the multi-threaded track, amazing victory!

Organizers would like to hear your frank feedbacks