1st OpenFOAM HPC Challenge (OHC-1): Hardware Track Summary

JULY 1, 2025, VIENNA

Mini-symposium to be held in the auspices of the
2025 OpenFOAM Workshop

Organized by the OpenFOAM HPC Technical Committee (TC)

Presented by:
Sergey Lesnik, Gregor Olenik, Mark Wasserman

Agenda

Time	Topic
11:00	Introduction
11:20	Summary of Contributions for the Hardware Track
11:40	Hardware Track Participant Talks
12:00	*Lunch break*
13:30	Hardware Track Participant Talks + Discussion
14:30	Summary of Contributions for the Software Track
14:50	Software Track Participant Talks
15:30	*Afternoon coffee break*
15:50	Software Track Participant Talks
16:10	Software Track Discussion
16:30	Summary + Next Steps for OHC
16:50-17:50	Extension possibility

HW Track Talks

Elisabetta Boella
Ruggero Poletto
Eike Tangermann
Lydia Schulze
Gabriel Marcos Magalhães
Aleksander Dubas

SW Track Talks

Sergey Lesnik
Simone Bnà
Stefano Oliani
Gregor Olenik
Henrik Rusche
Mark Wasserman

Contributors

- **240+ data points contributed by 12 contributors:**
  - Wikki GmbH
  - UCD
  - CFD FEA Service
  - Cineca
  - Huawei
  - Universität der Bundeswehr München
  - Federal Waterways Engineering and Research Institute
  - University of Minho
  - Technical University Munich
  - United Kingdom Atomic Energy Authority
  - Engys
  - E4 Computer Engineering

Thank you!

Breakdown of Contributions (Statistics)

- **Total number of valid entries: 236**
  - Hardware track entries 175, Software track entries 61
  - AMD 106, Intel 80, ARM 50
- 25 different CPU models and 3 GPU models

- Max nodes used: 256
- Max cores used: 32768
- Min wall-clock time to solution: 7.8 minutes
- Max wall-clock time to solution: 65.7 hours
- Min energy of single simulation: 2.1 [kWh]
- Max energy of single simulation: 236.9 [kWh]

Breakdown of Contributions (Statistics)

- Total reported energy consumption:

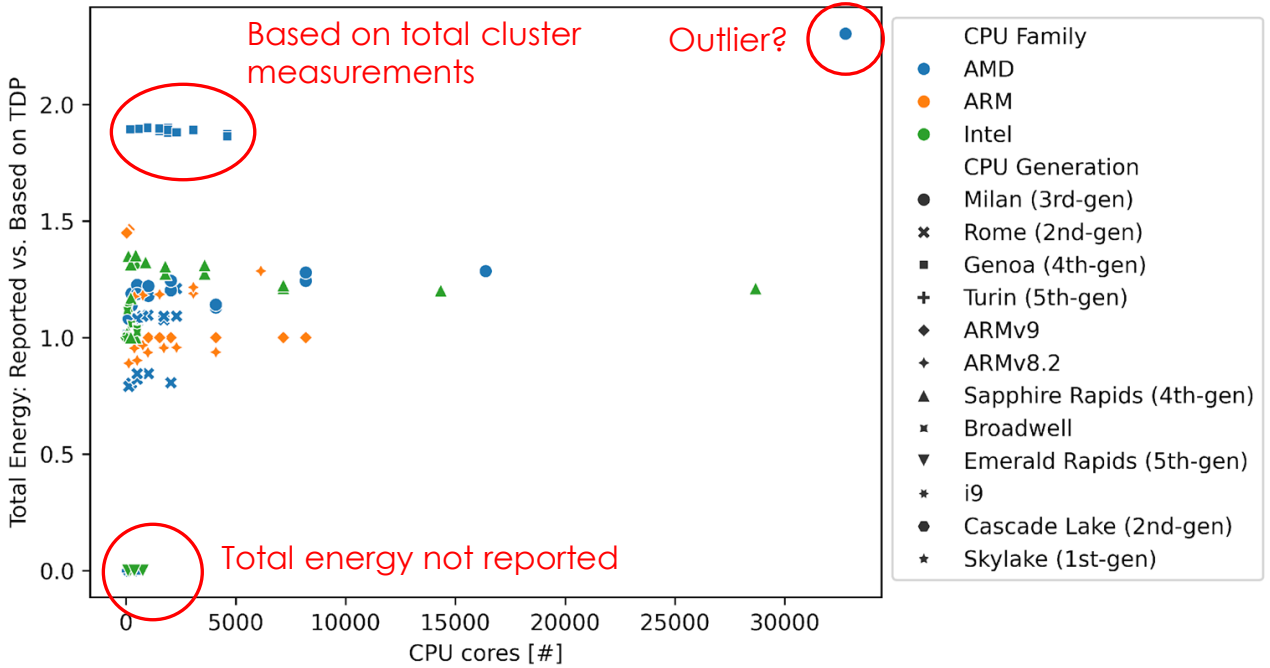
  4715.37 kWh, potentially bringing ~169 bath tubs to a boiling point!

Issues, Assumptions and Disclaimers

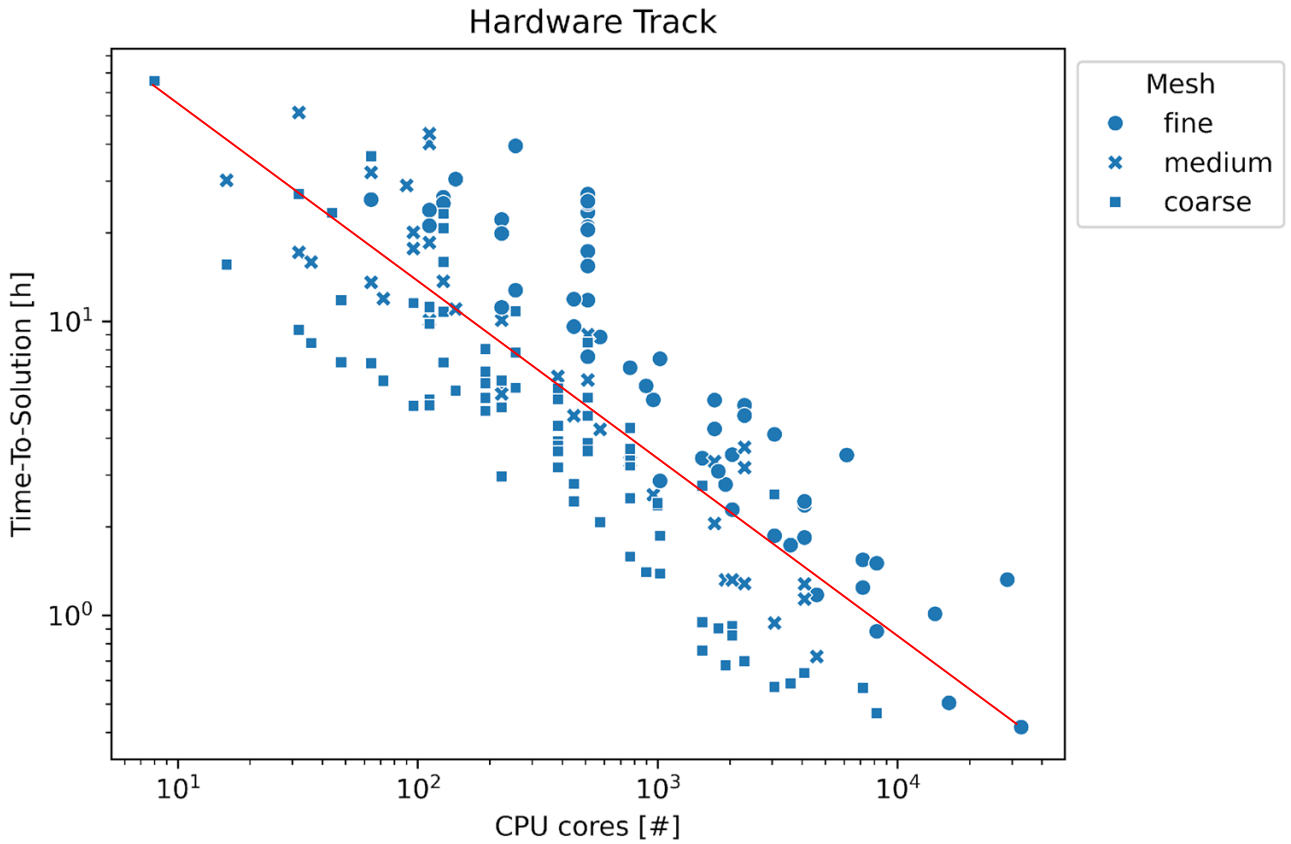
- **No. of cores was corrected to represent physical cores (hyper-threading disregarded)**
- **Changed names/values to adhere to a predefined scheme for easier evaluation**
- **Added some values based based on publicly available data (e.g. TDP according to the CPU model)**
- **The focus lied on providing an overview of the complete data set, not analysis of single simulations or submissions - the latter are covered by the participants' talks**

Issues, Assumptions and Disclaimers

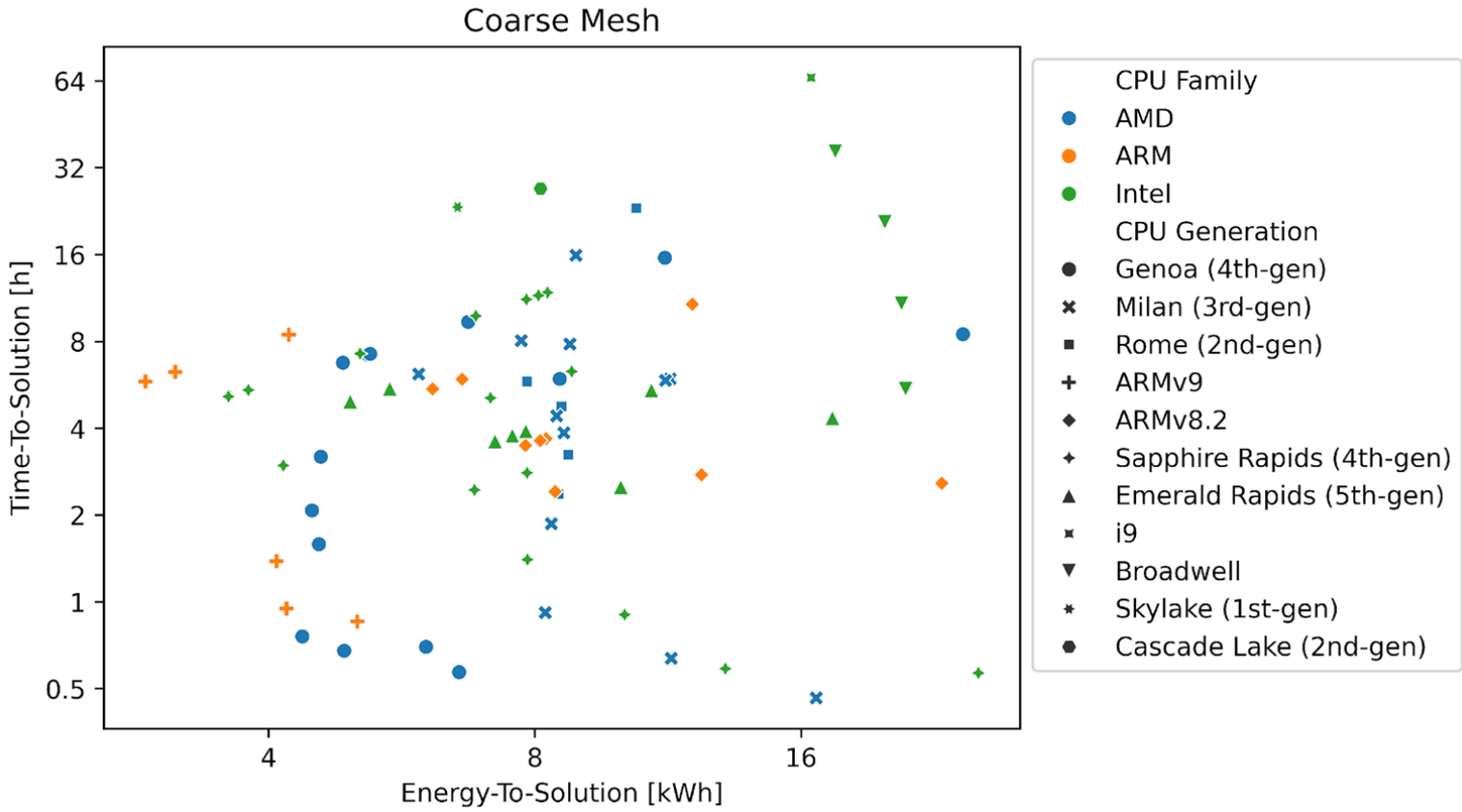
- **Energy analysis mostly based on theoretical TDP values**



Breakdown of Contributions (plot)



Energy vs. WCT (per mesh)



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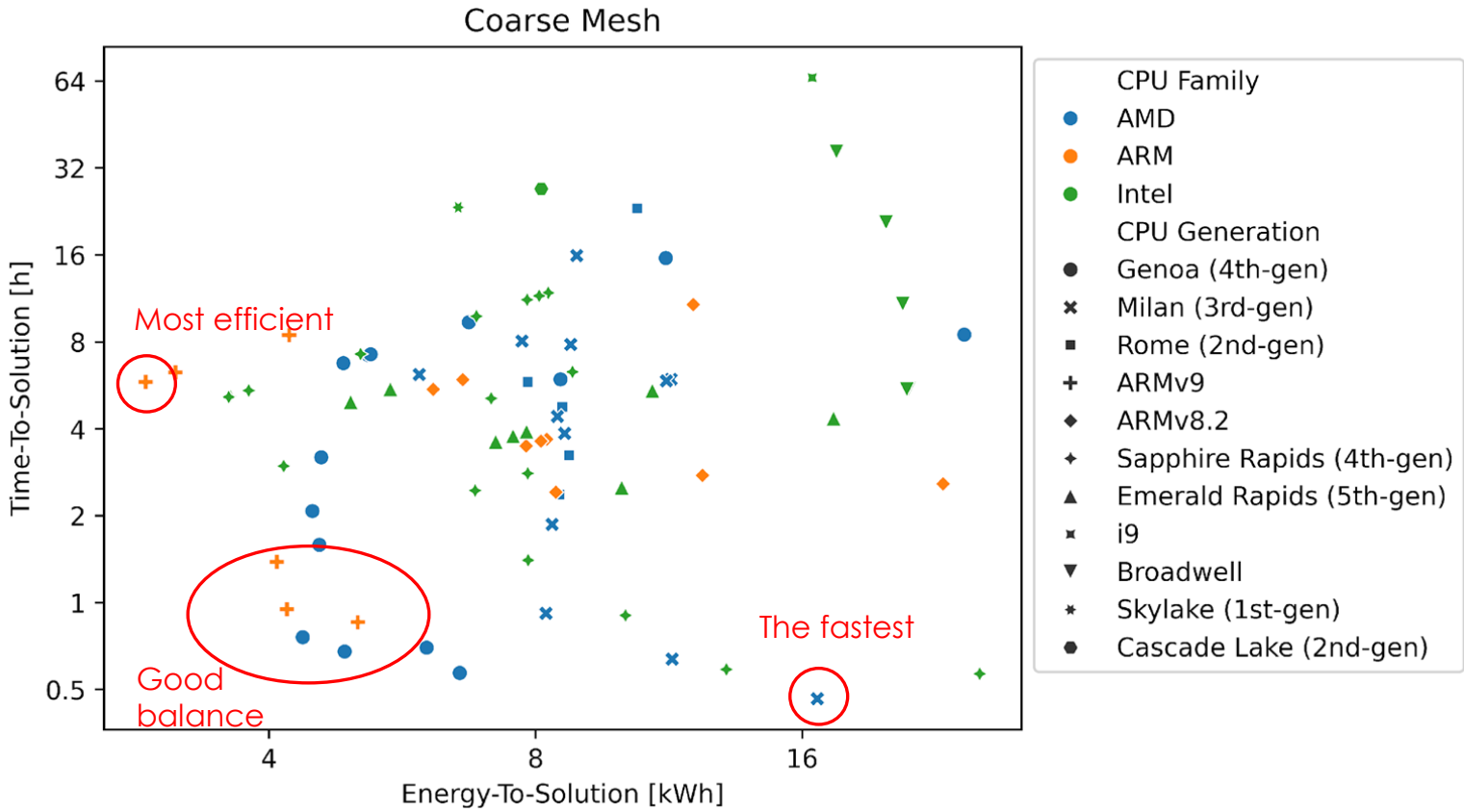

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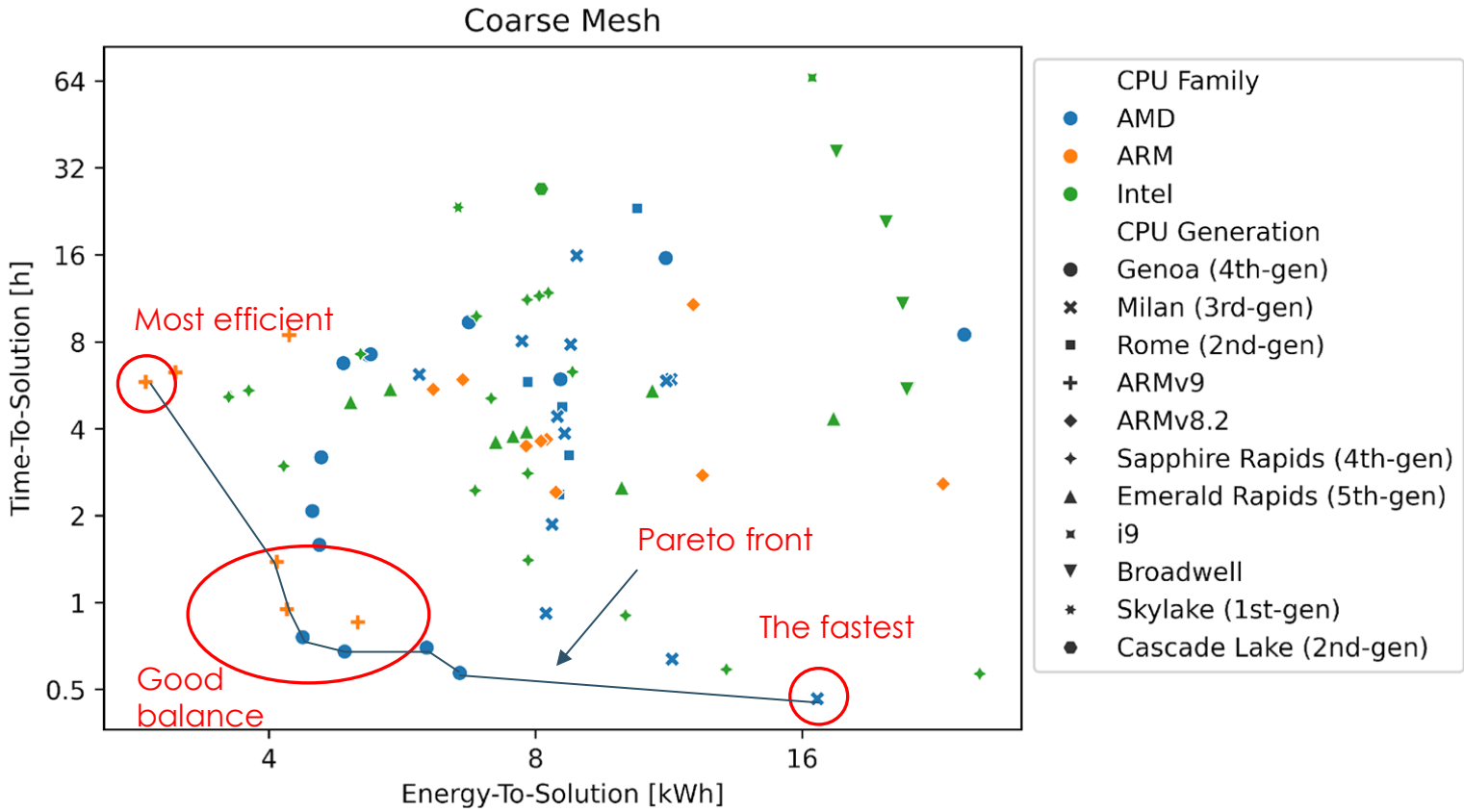

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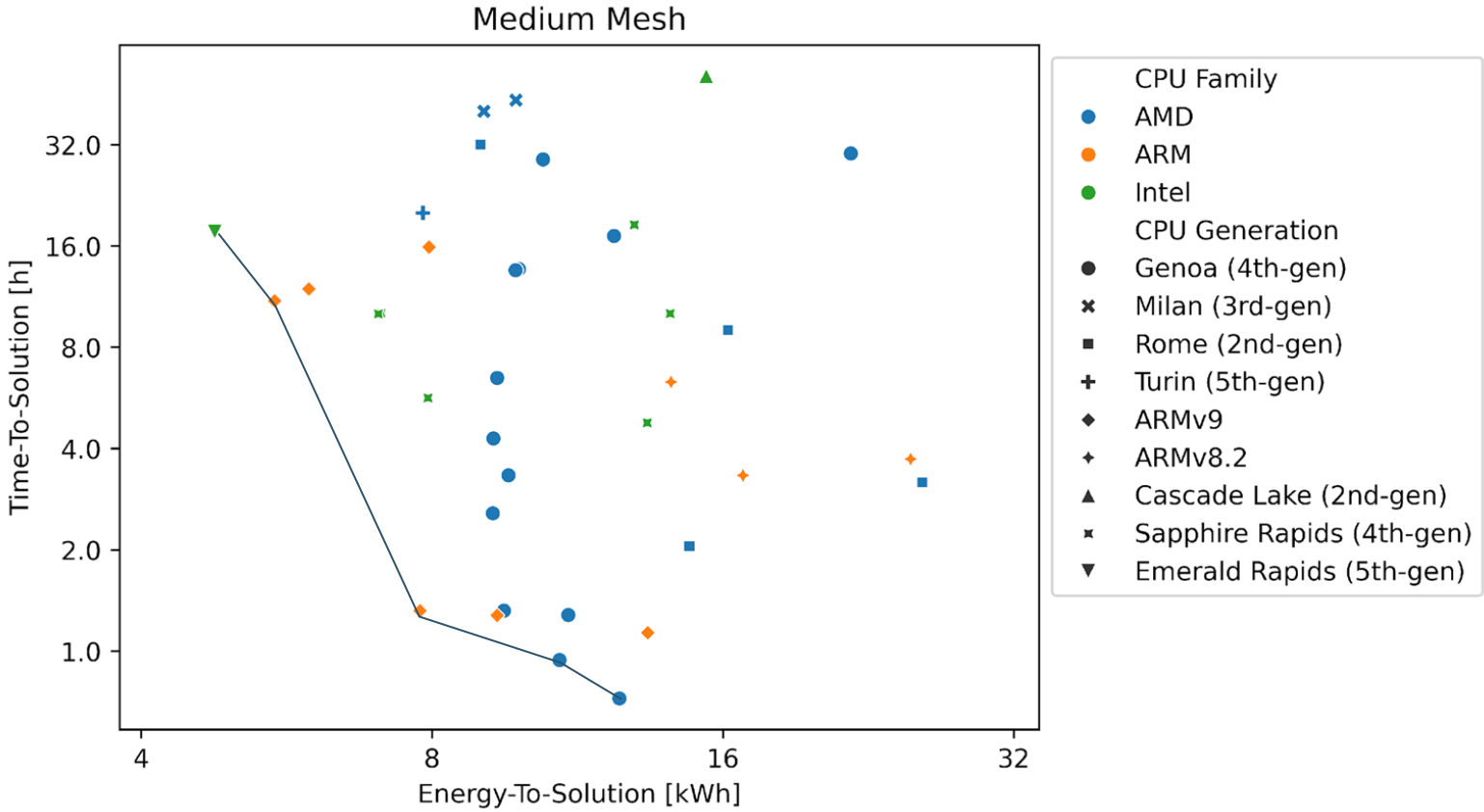
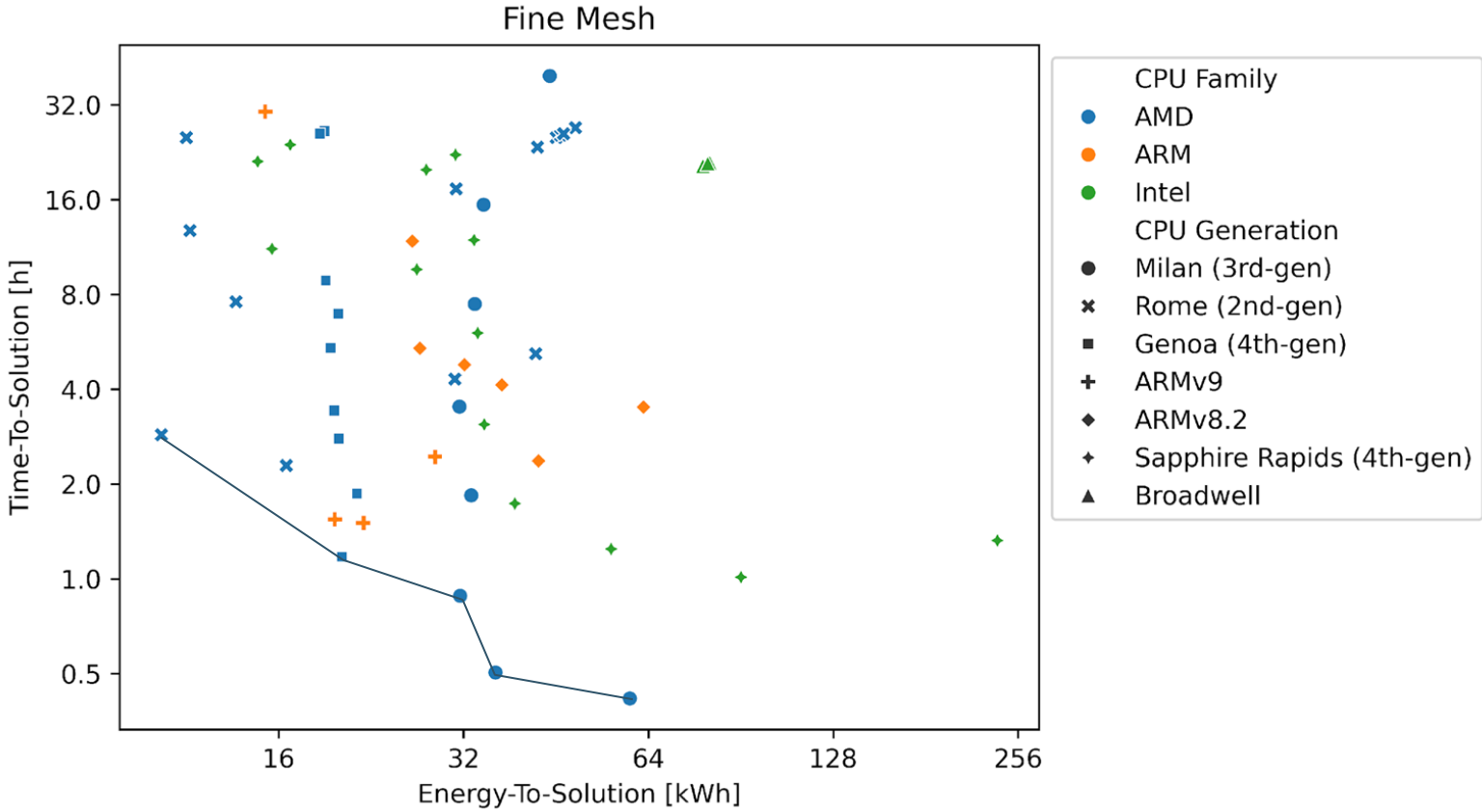
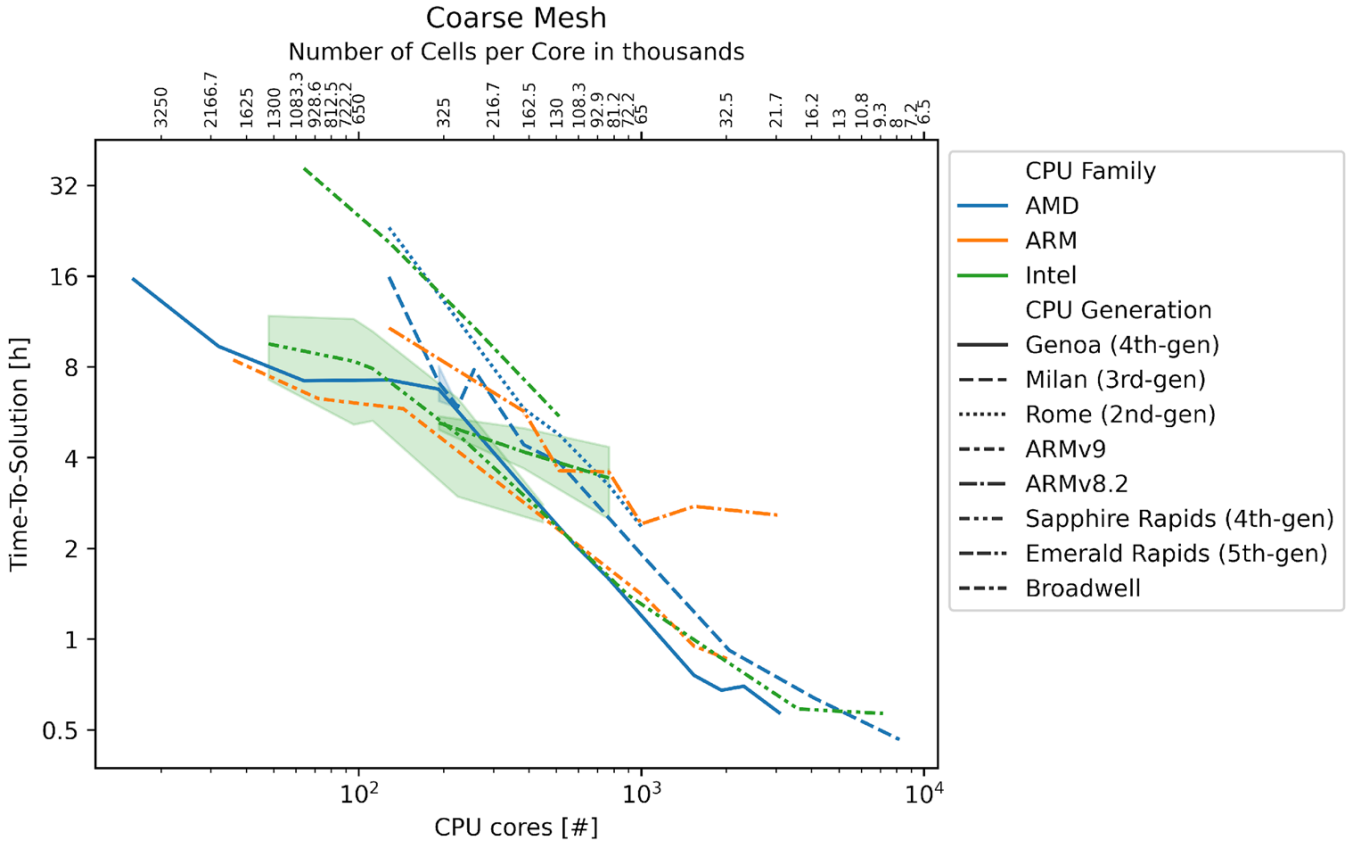


Energy vs. WCT (per mesh)



Scalability Limits (Strong Scaling)



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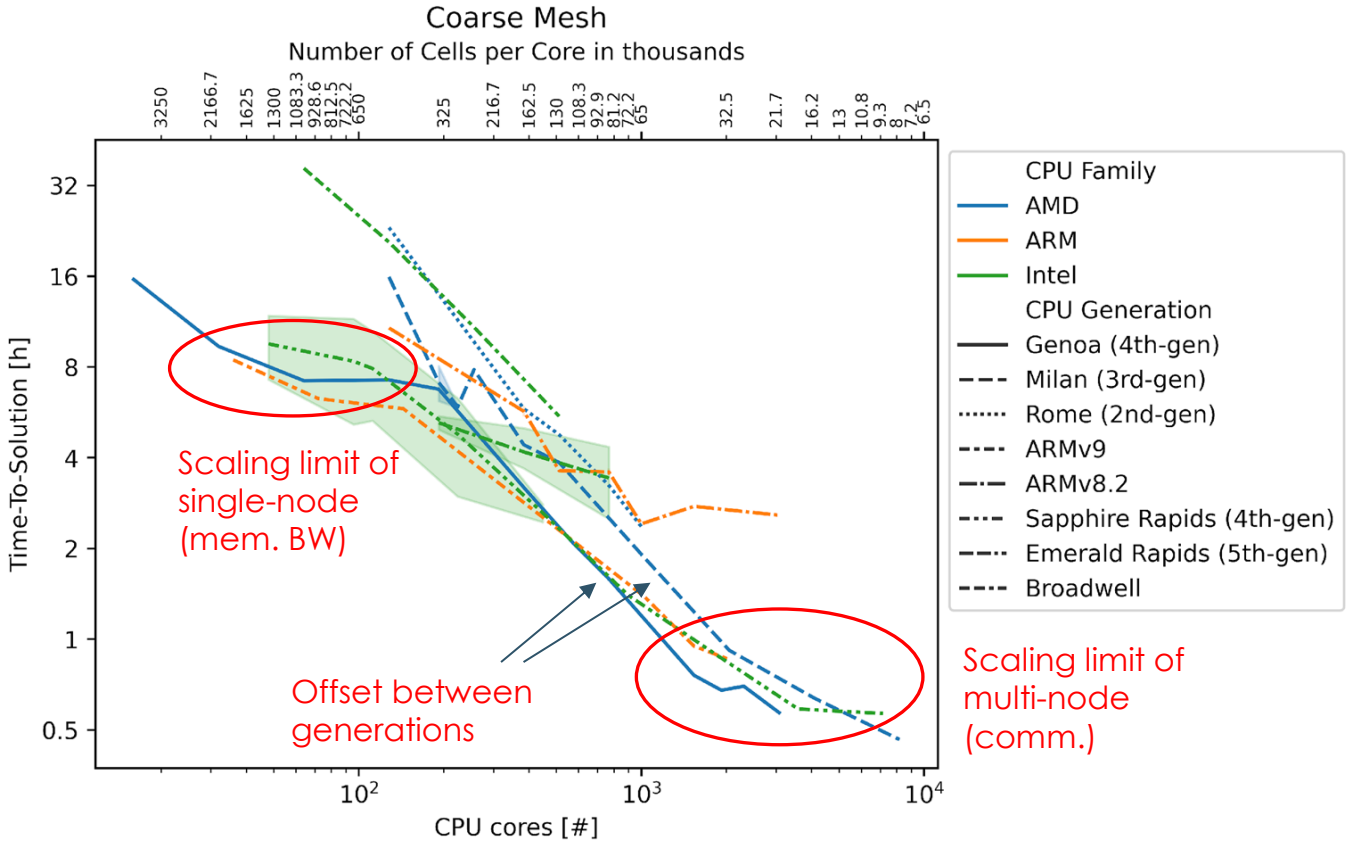

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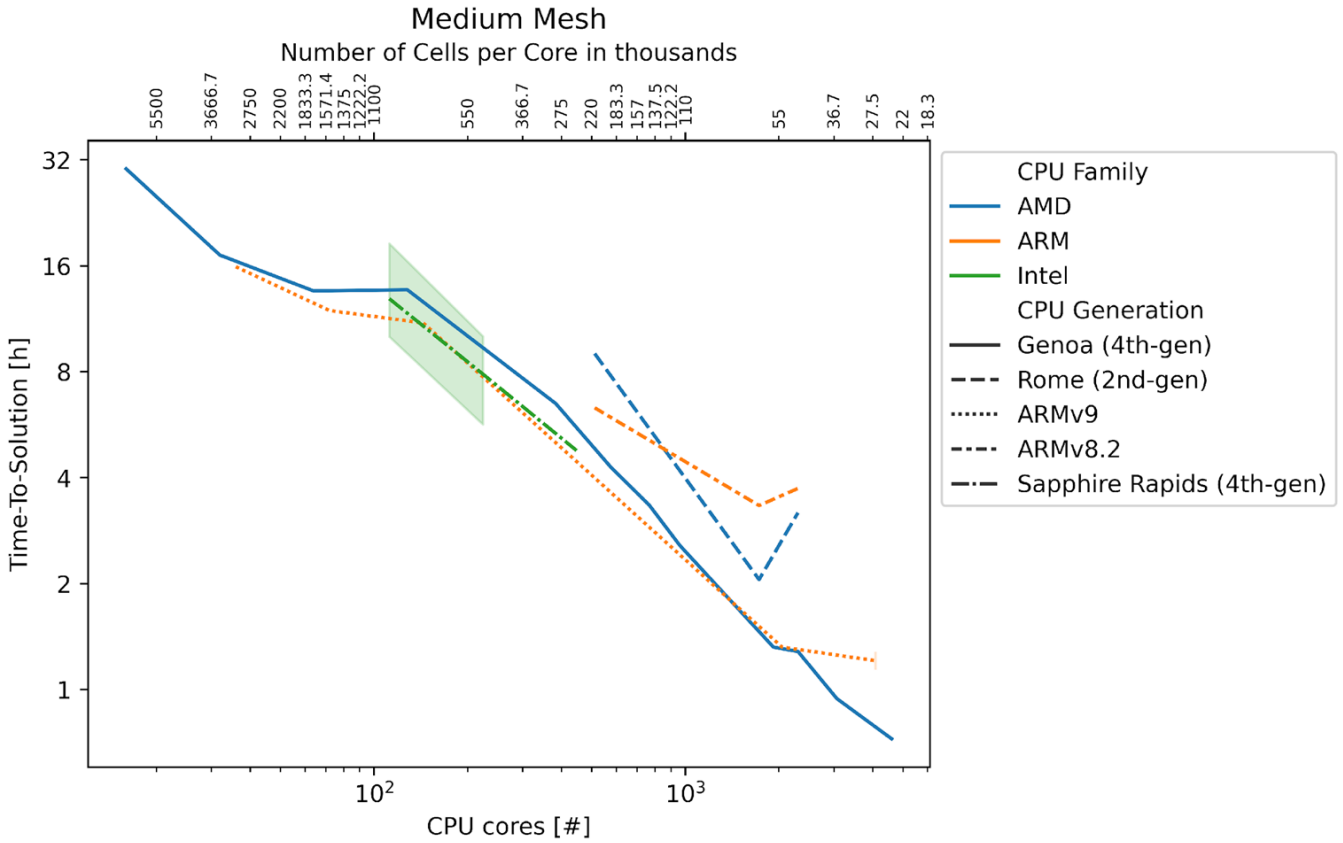

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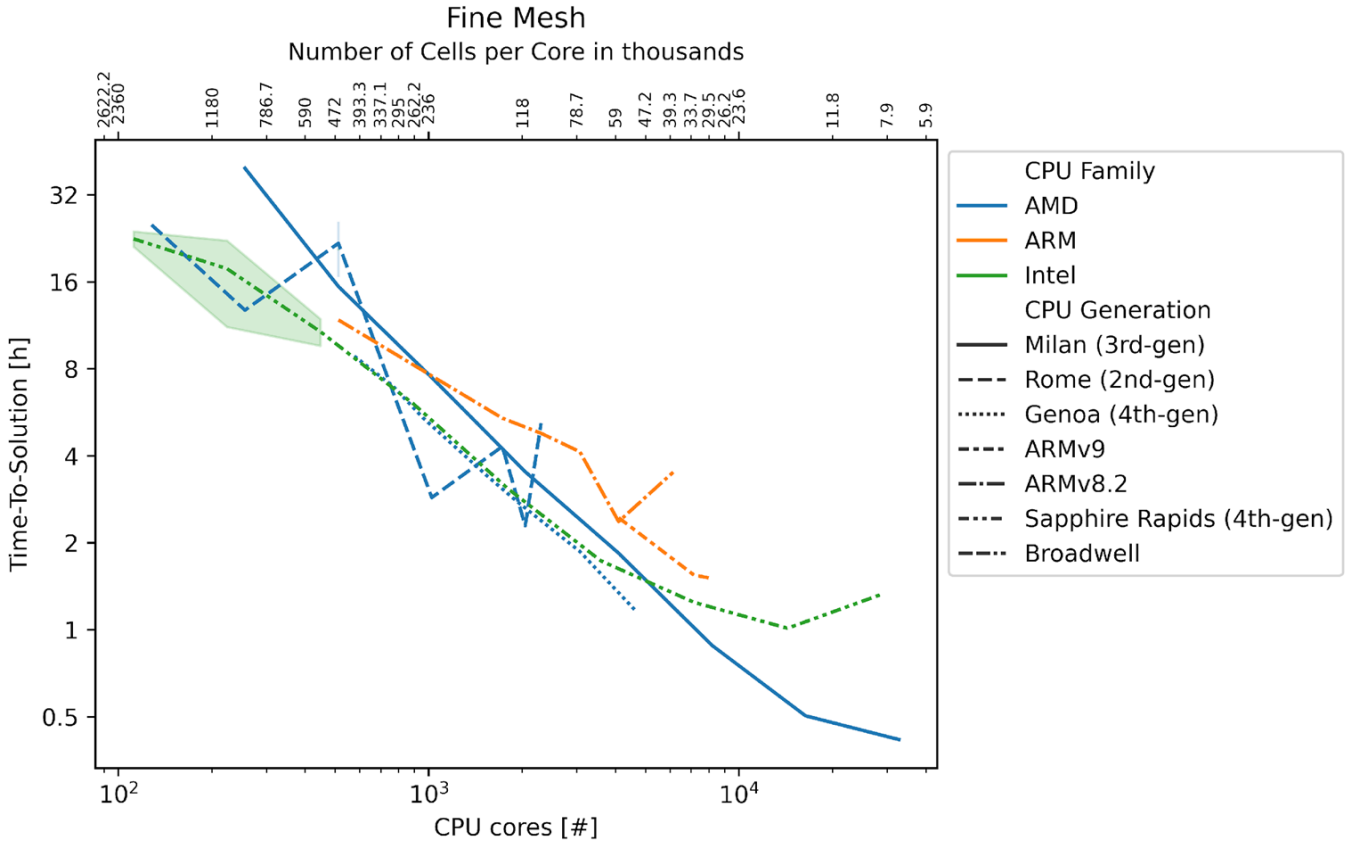
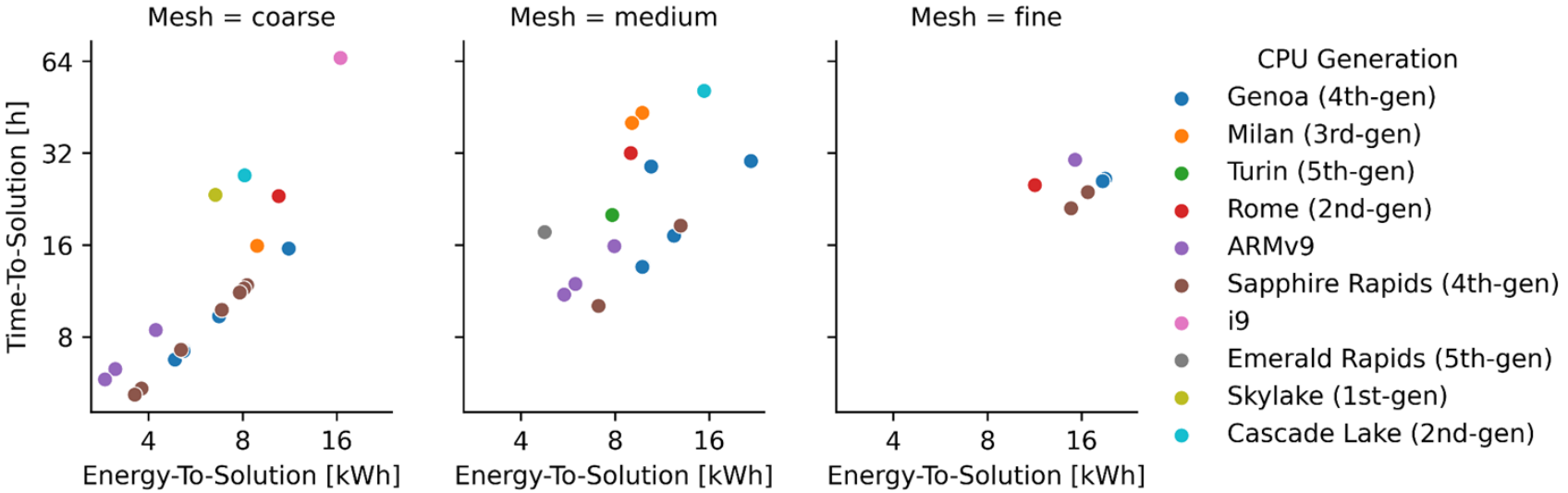
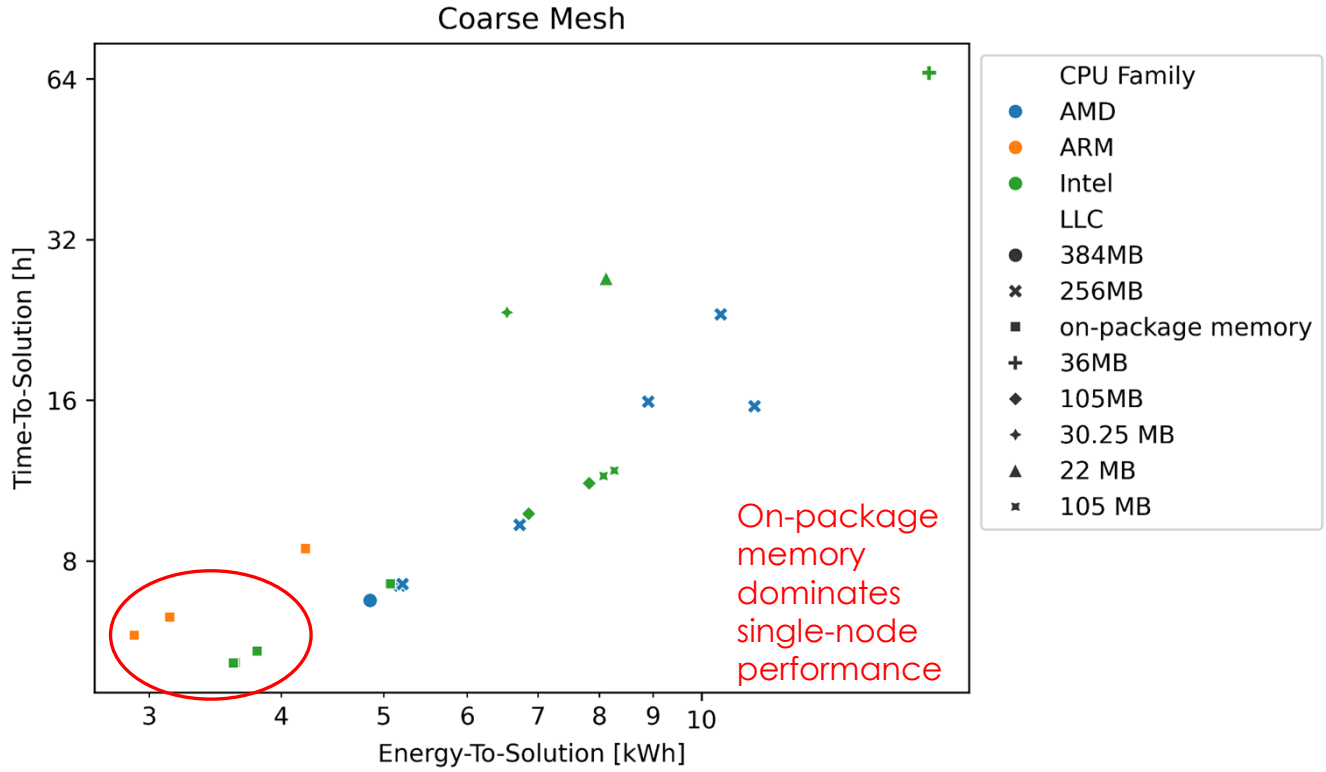


Single-node Performance



HBM/LLC Effect



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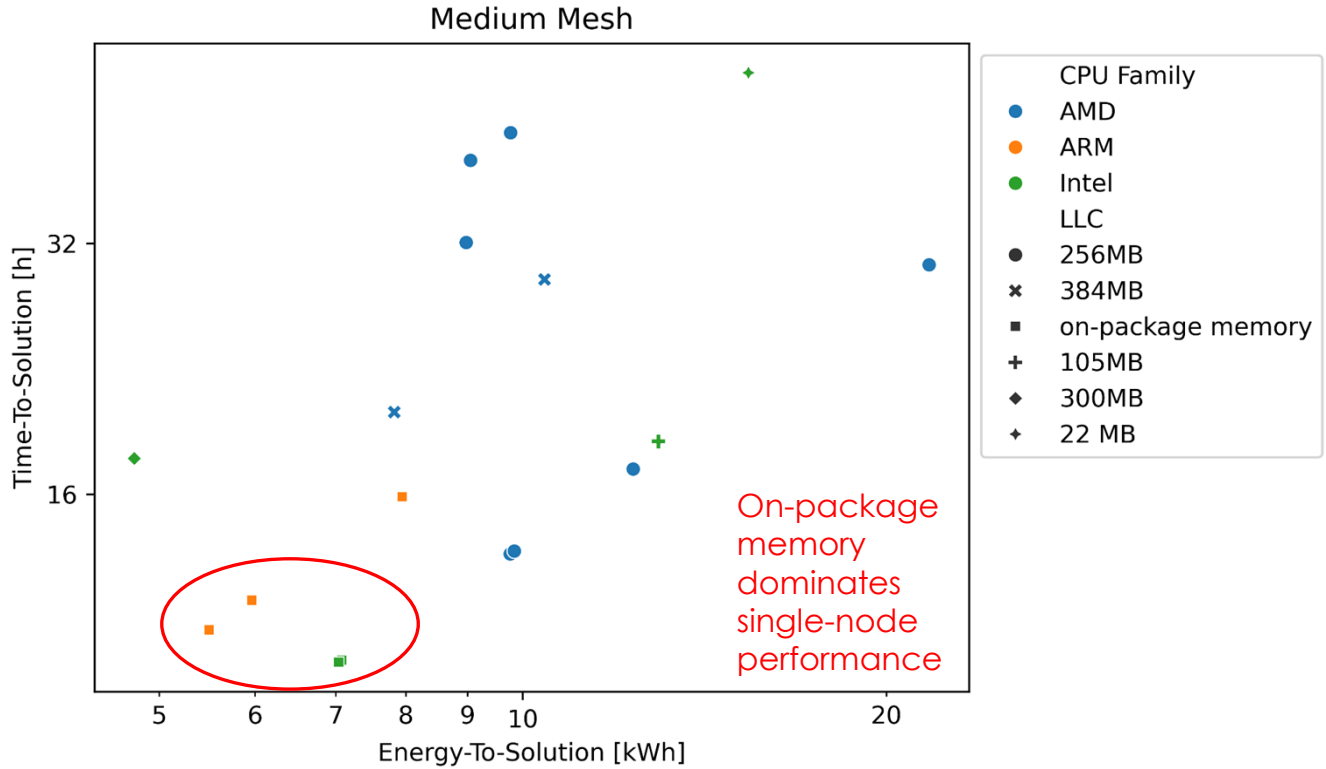

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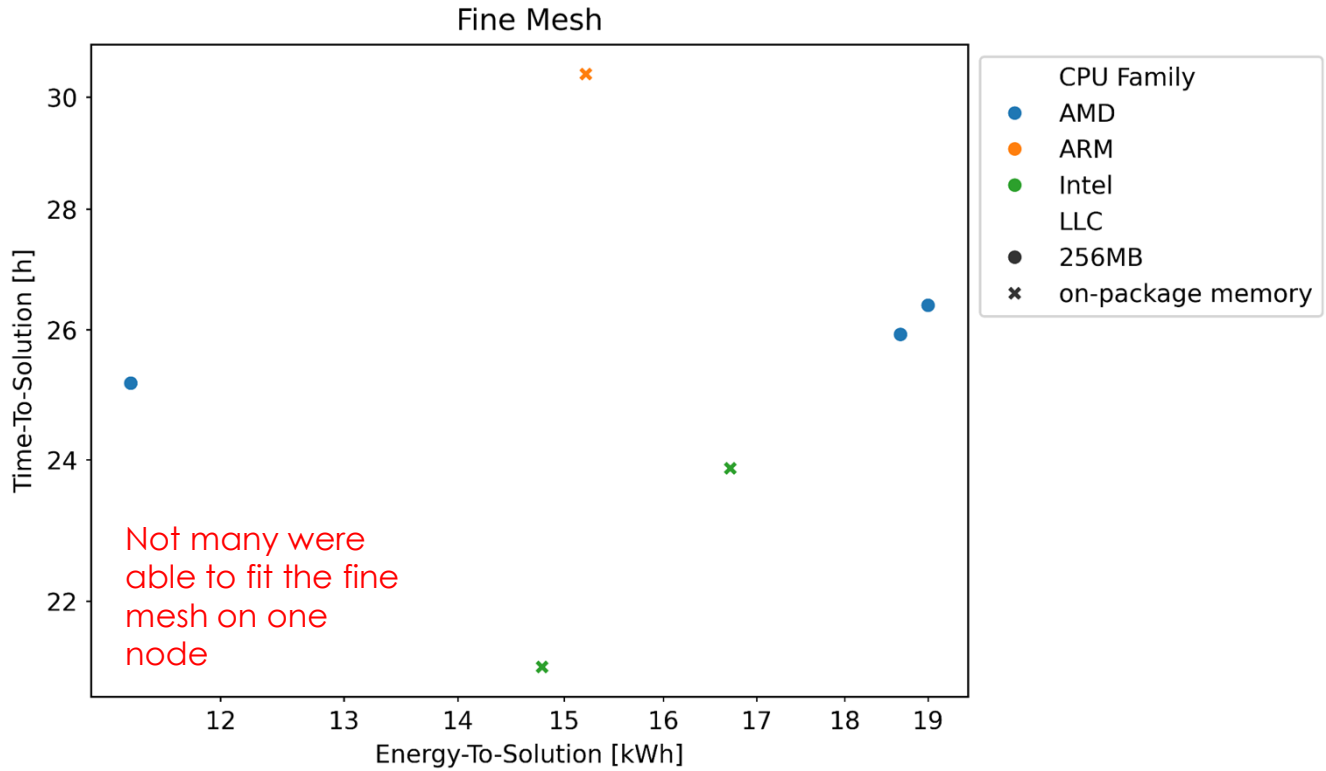
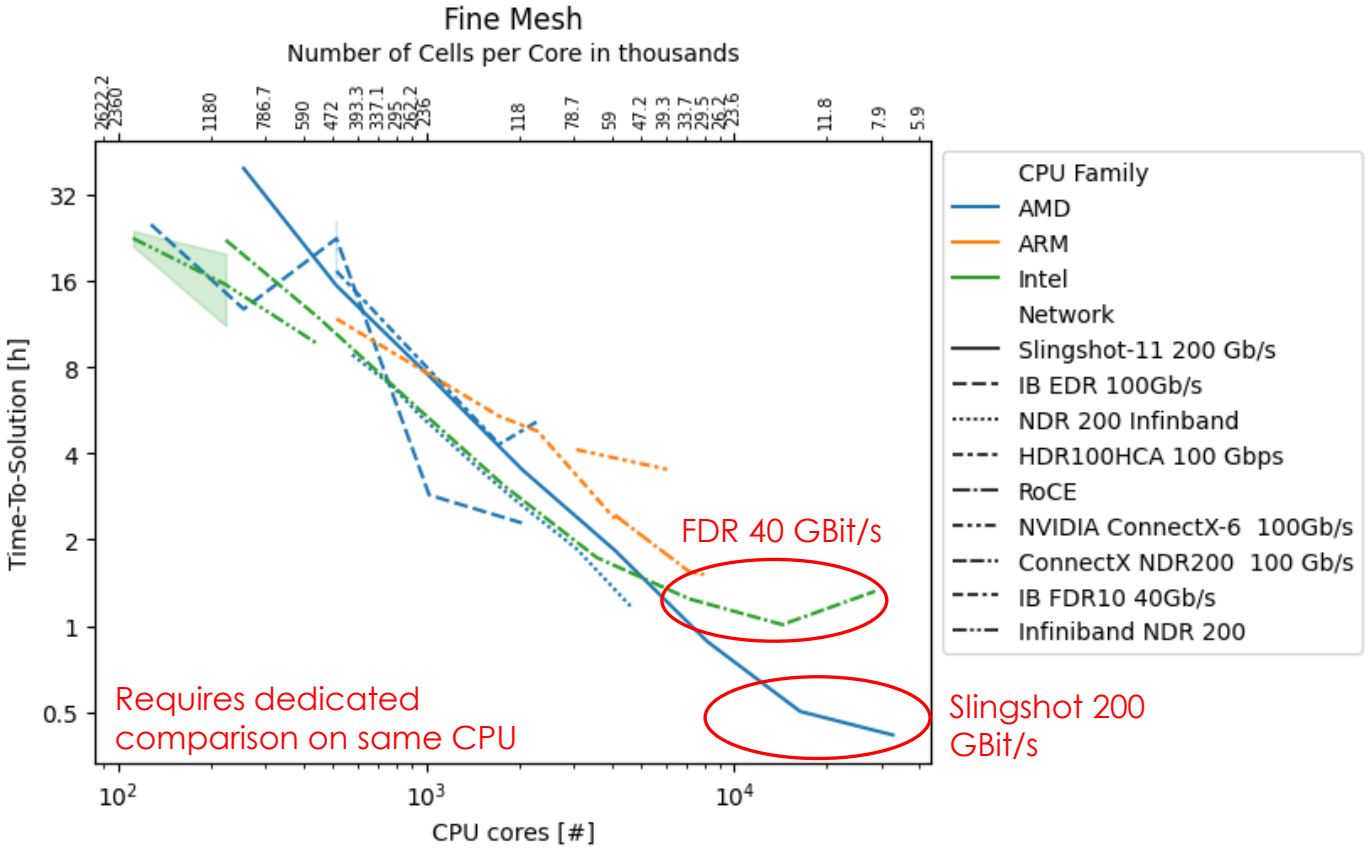


Network Interconnect Effect (Optional)



Summary

- Contributions exceeded our expectations, but submission format needs to be tighter for next time
- Identified pareto front of optimal balance between time-to-solution and energy-efficiency
- At small-scale, next-gen CPUs (ARM, Intel, AMD) show improved performance thanks to introduction of on-package, high-bandwidth memory and many-core architecture
- At large-scale, communication dominates performance and many-core architectures pose challenge to OpenFOAM (only MPI parallelism)
- OpenFOAM scales well up to 10k cells/core

- Data will be distributed to enable further analysis