Open-Source Thermal Modeling Tools

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Z. Yuan, P. Shukla, S. Chetoui, S. Nemtzow, S. Reda and A. K. Coskun,
"PACT: An Extensible Parallel Thermal Simulator for Emerging Integration and Cooling Technologies,"
IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, vol. 41, no. 4, pp. 1048-1061, April 2022.

TCAD Donald O. Pederson Best Paper Award 2024

University Demonstration at DAC 2024!

PACT: A Parallel Compact Thermal Simulator

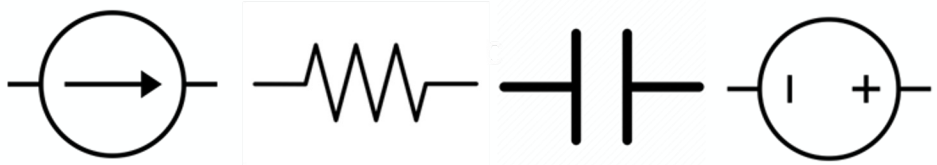
- Fast and accurate
- Standard-cell level to architecture-level
- Interface to OpenROAD
- High extensibility
- Open-source: https://github.com/peaclab/PACT
- VisualPACT

PACT Simulation Flow

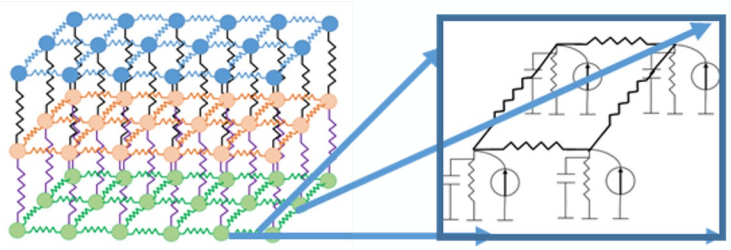
User inputs

- Chip stack descriptions (e.g., floorplan, # of layers, power traces)
- # of grids and heat sink type
- Material properties and cooling method

Calculate netlist components



Thermal netlist generator



SPICE Engine

Outputs

Parallel configuration (OpenMPI)

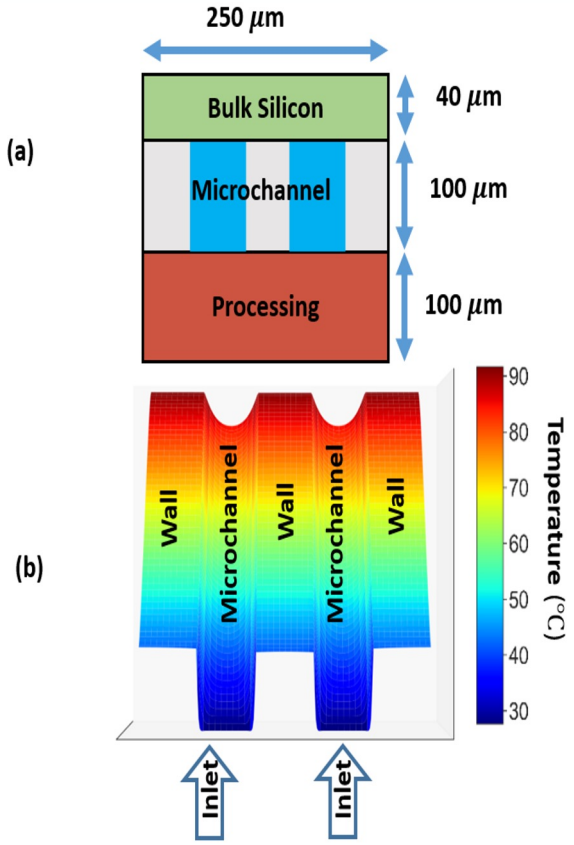
- # of Node, # of Cores
- Parallel Option (e.g., -bind-to none)
- Job mapping option (e.g., -cpu-set)

Simulation type and solver selection

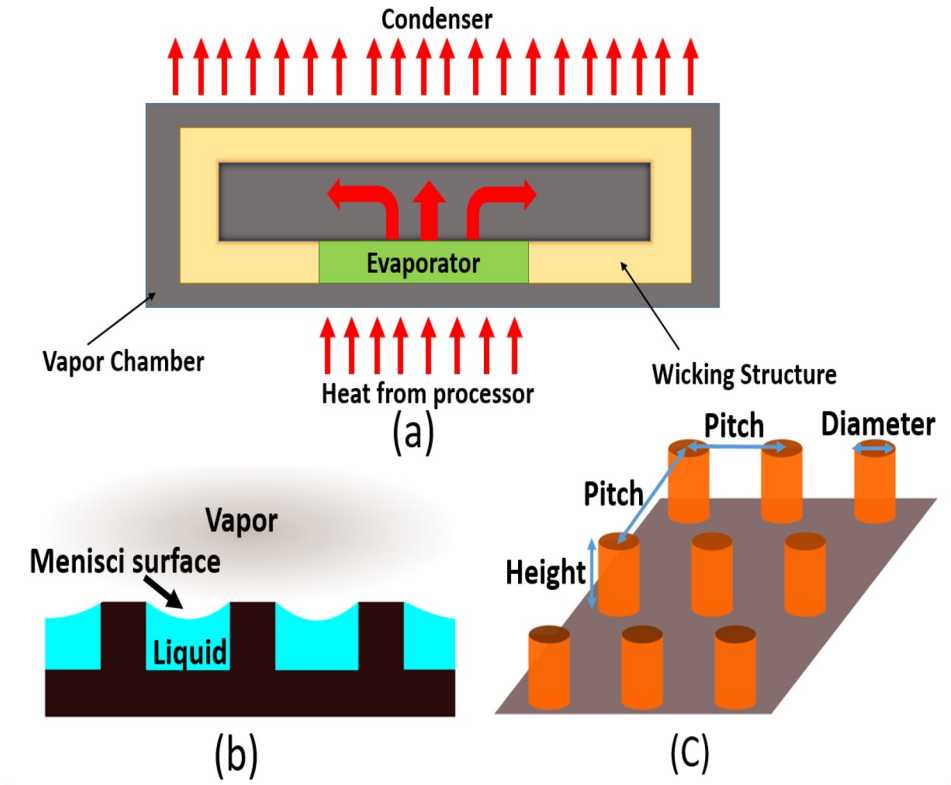
- Steady-state simulation (e.g., KLU, KSparse)
- Transient simulation (e.g., Backward Euler, Trapezoidal)
- Other simulation options (e.g., time period, step size)

Extensibility of PACT

Monolithic 3D design test case

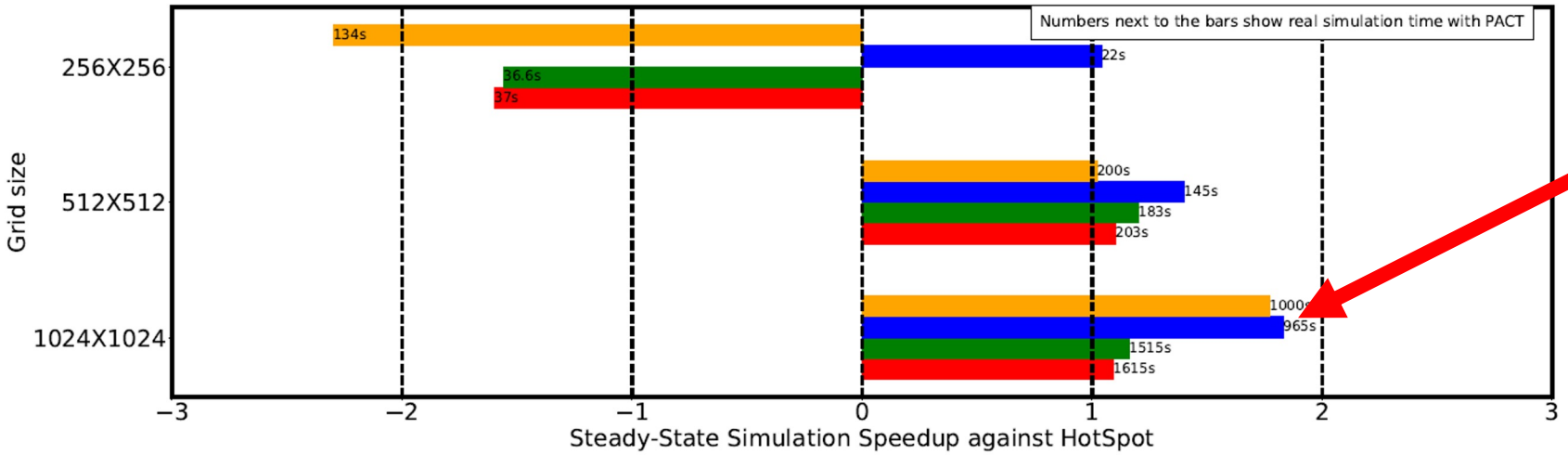


Liquid cooling via microchannel

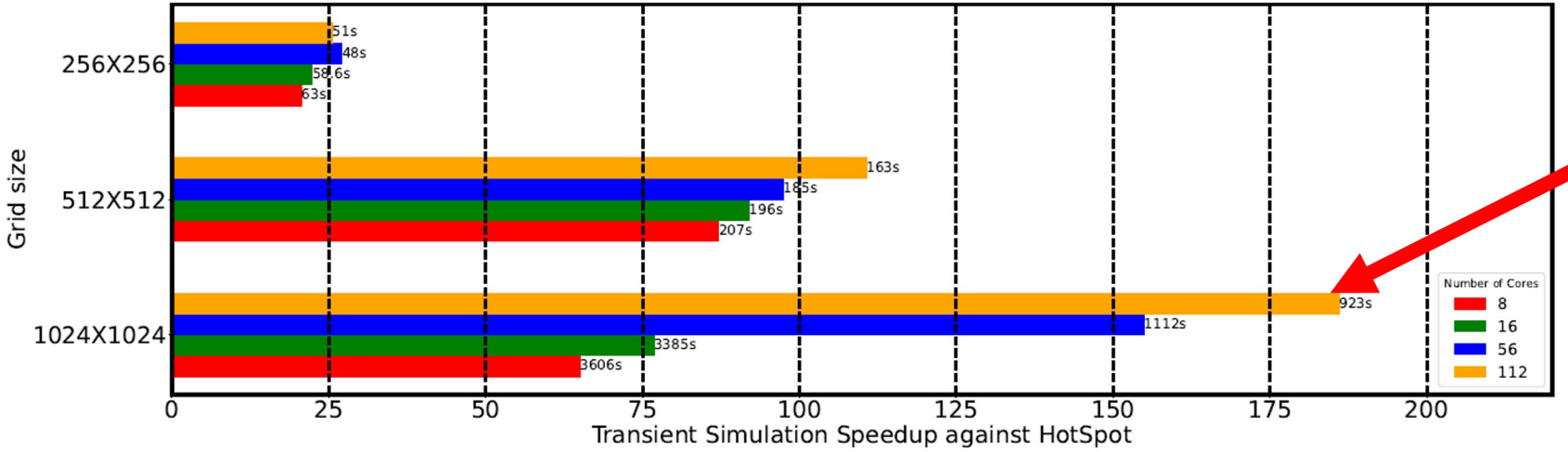


Two-Phase Vapor Chambers (VCs) with Micropillar Wick Evaporators

PACT Speed Analysis against HotSpot



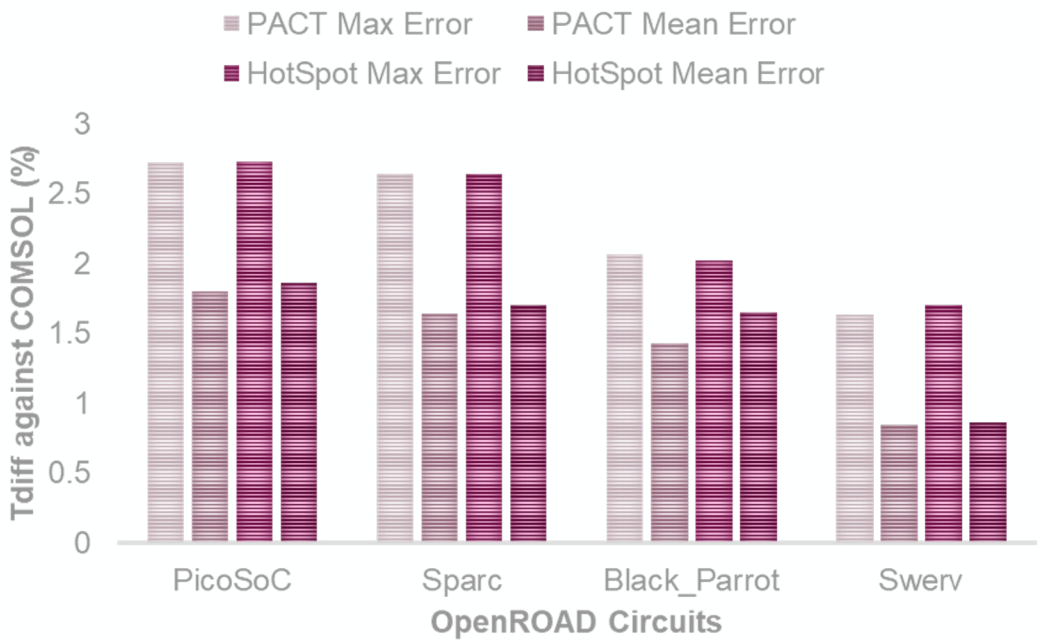
1.83X speedup



186X speedup

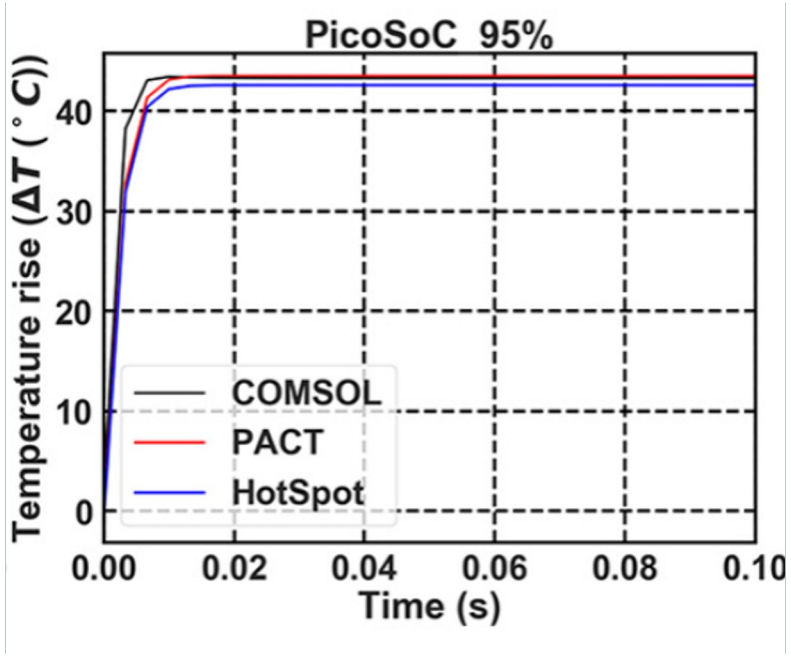
Validation with OpenROAD Benchmarks

Steady-State vs. HotSpot



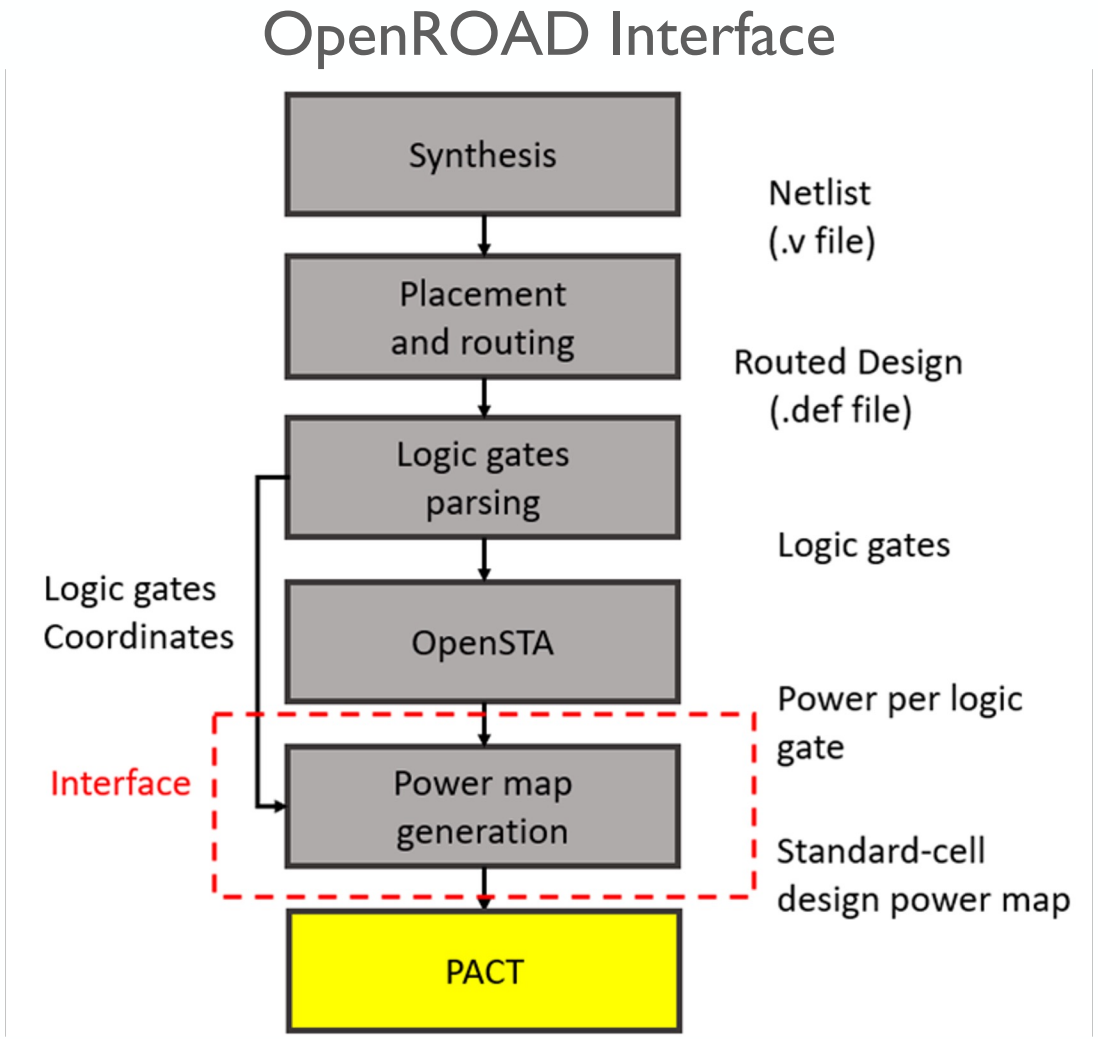
PACT vs. COMSOL (Max Steady-State Diff: 2.77%)

Transient vs. HotSpot

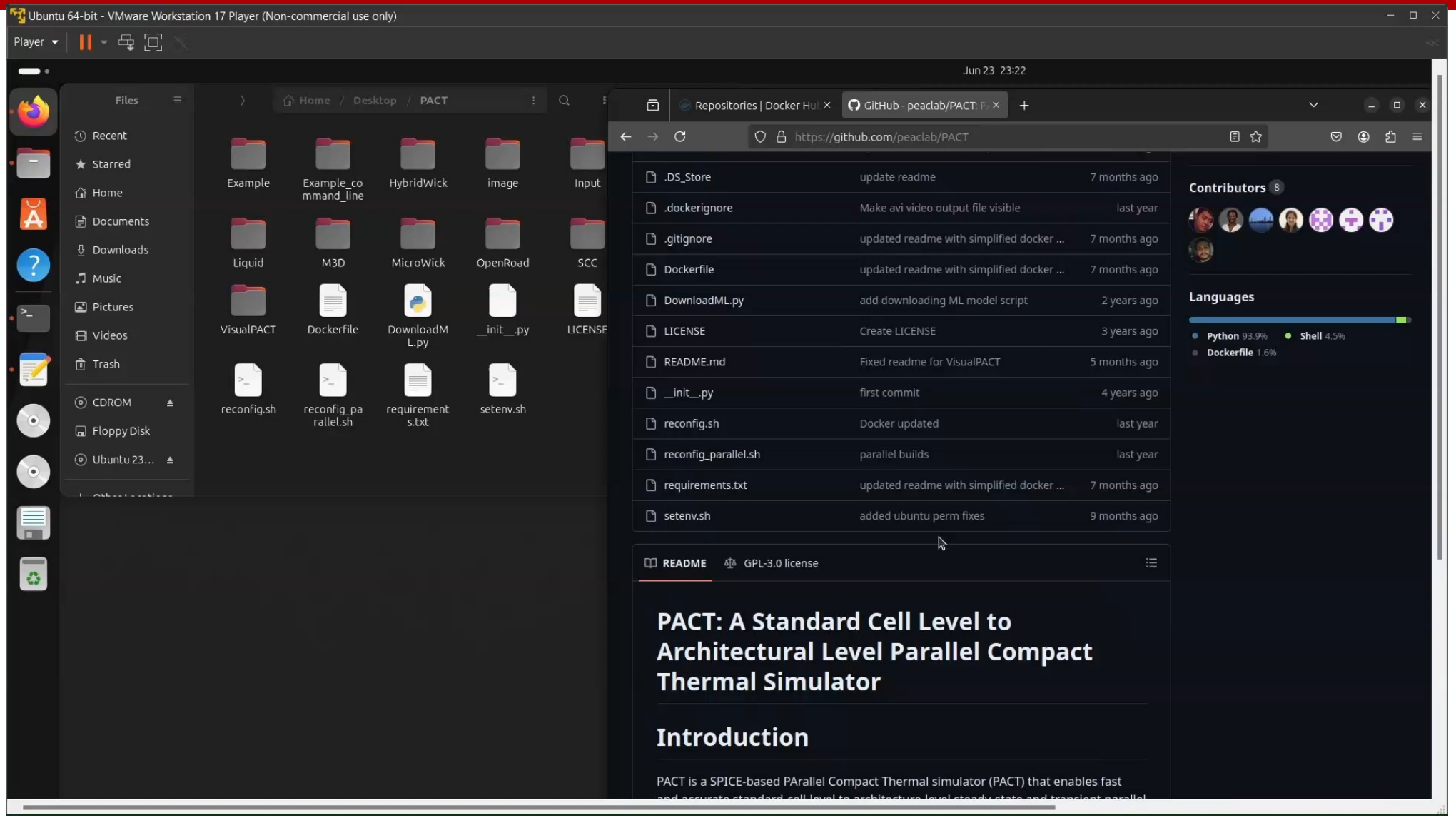


PACT vs. COMSOL (Max Transient Diff: 3.28%)

OpenROAD Interface



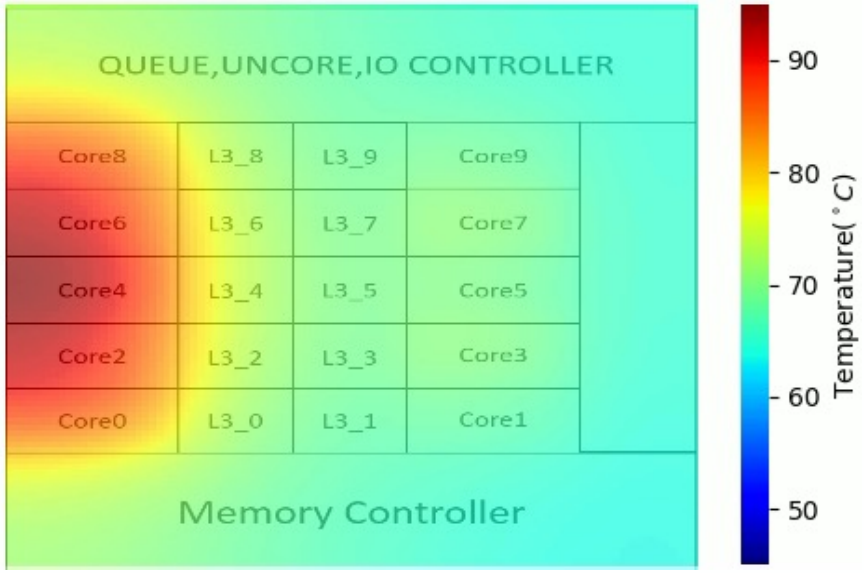
Containerized PACT



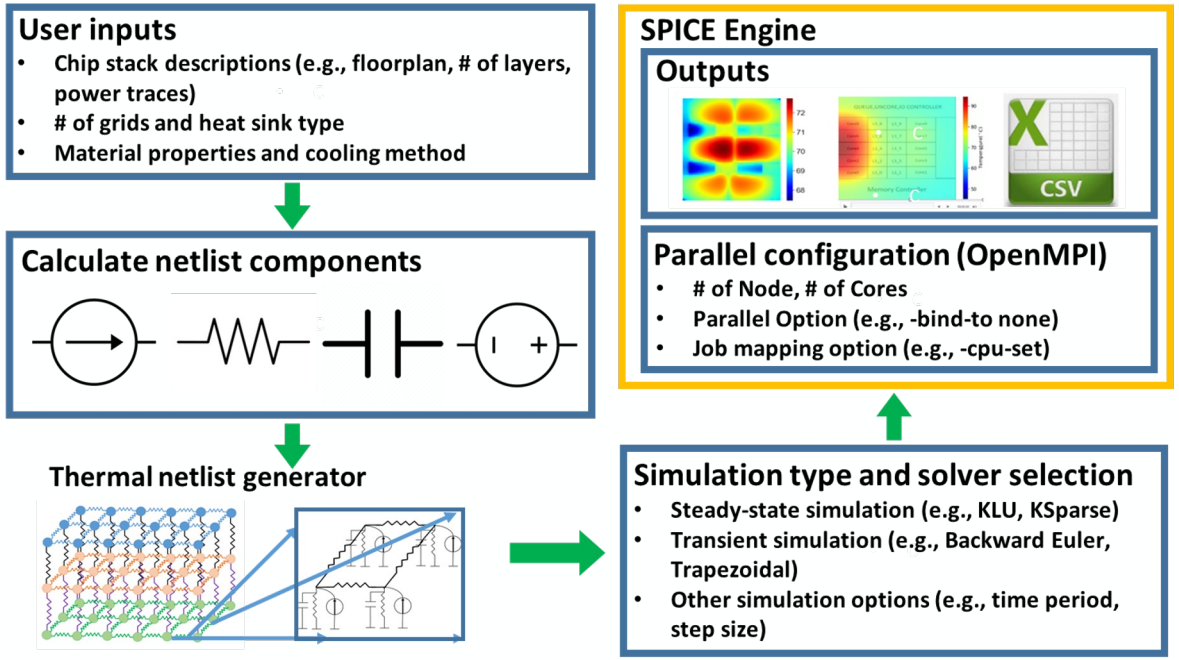
VisualPACT

- VisualPACT
  - Generating thermal videos for transient thermal simulations
  - Visualizing transient thermal behaviors of architectural simulations

VisualPACT (Intel i7 6950X)



- PACT
  - Fast and accurate parallel thermal simulator
  - Architecture level & standard-cell level
  - High extensibility for emerging cooling methods
  - Various numerical solvers
  - OpenROAD interface
  - VisualPACT
  - Containerized version



PACT user group:
https://groups.google.com/g/pact-simulator

More info at:
https://github.com/peaclab/PACT