



Brown
University
Scale Lab

Open-Source Thermal Modeling Tools

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Z. Yuan, P. Shukla, S. Chetoui, S. Nemptzow, 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



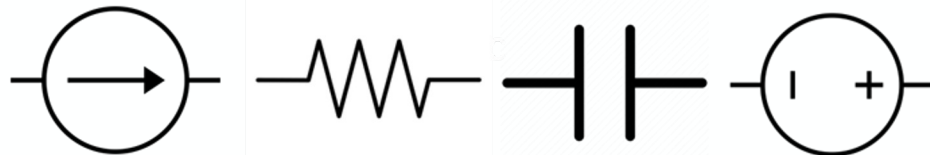
PACT Simulation Flow

User inputs

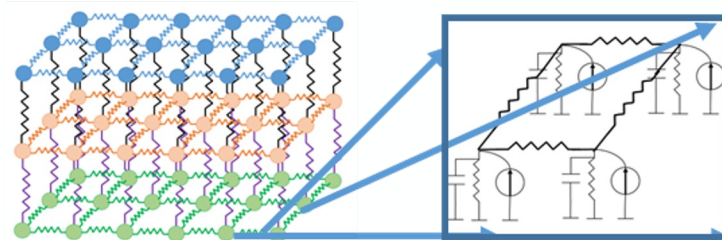
- Chip stack descriptions (e.g., floorplan, # of layers, power traces)
- # of grids and heat sink type
- Material properties and cooling method



Calculate netlist components

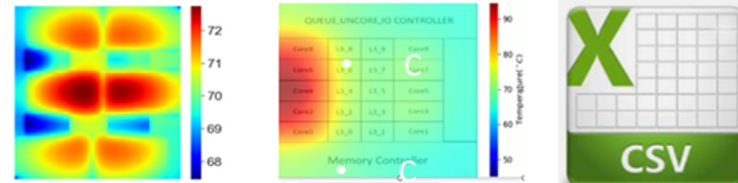


Thermal netlist generator



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

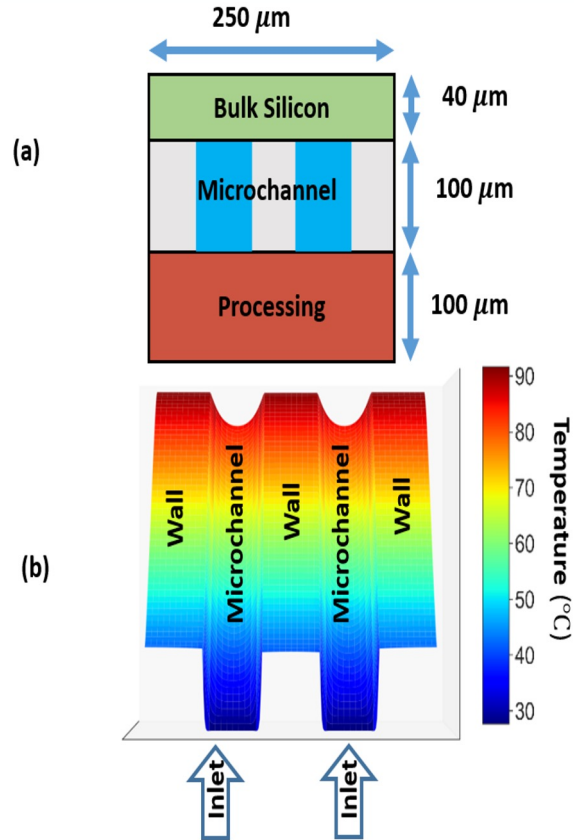
- Steady-state simulation (e.g., KLU, KSparse)
- Transient simulation (e.g., Backward Euler, Trapezoidal)
- Other simulation options (e.g., time period, step size)



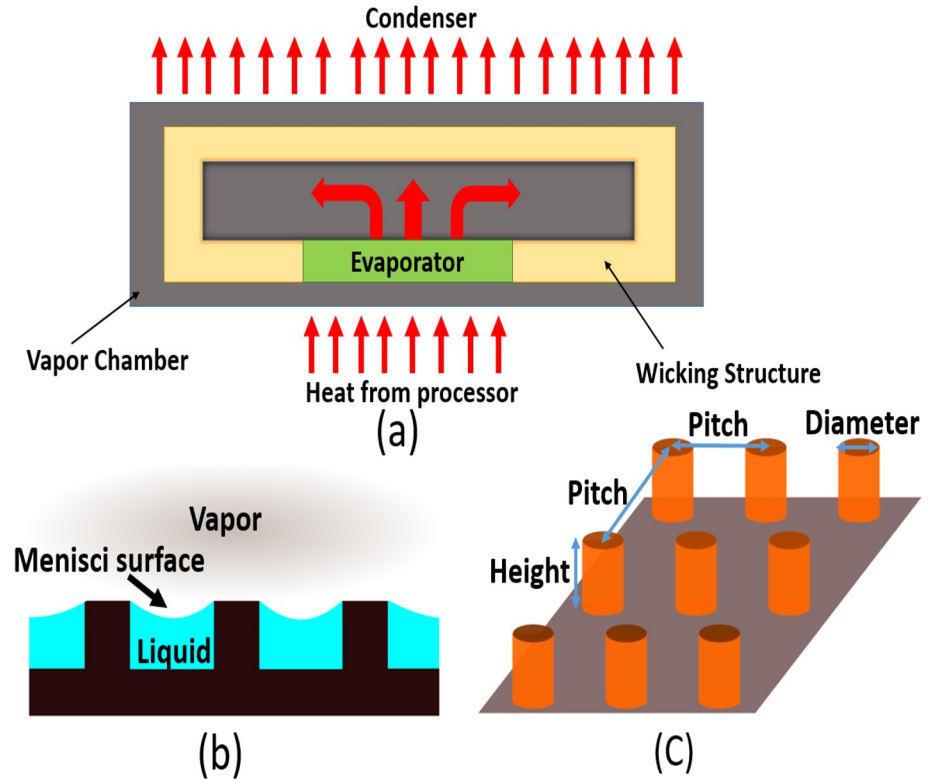
Extensibility of PACT



Monolithic 3D design test case



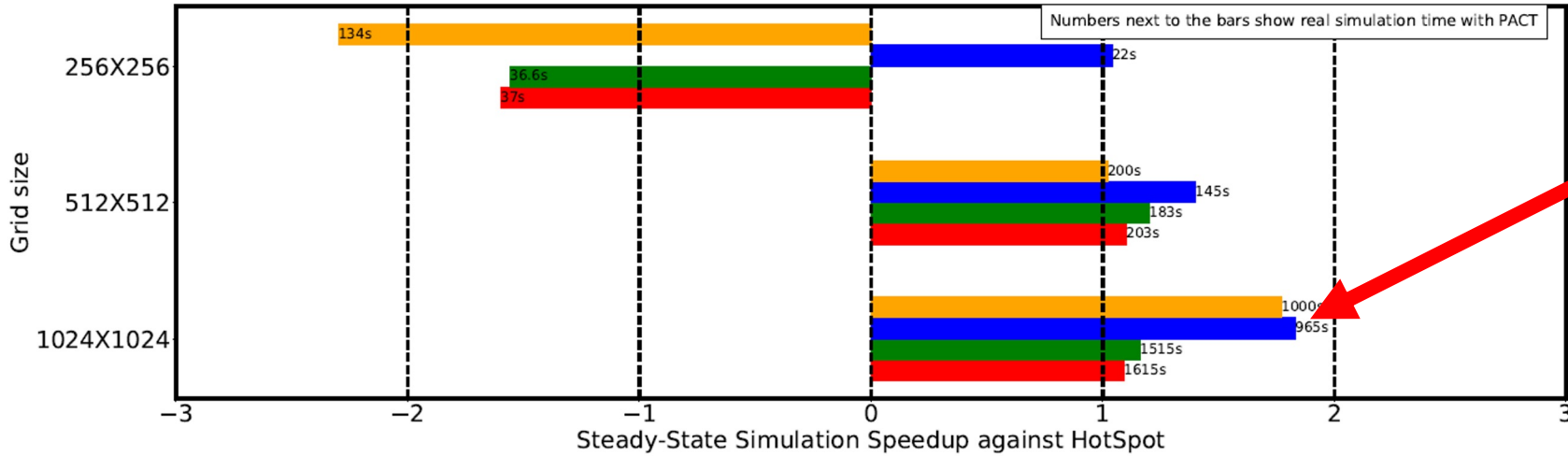
Liquid cooling via microchannel



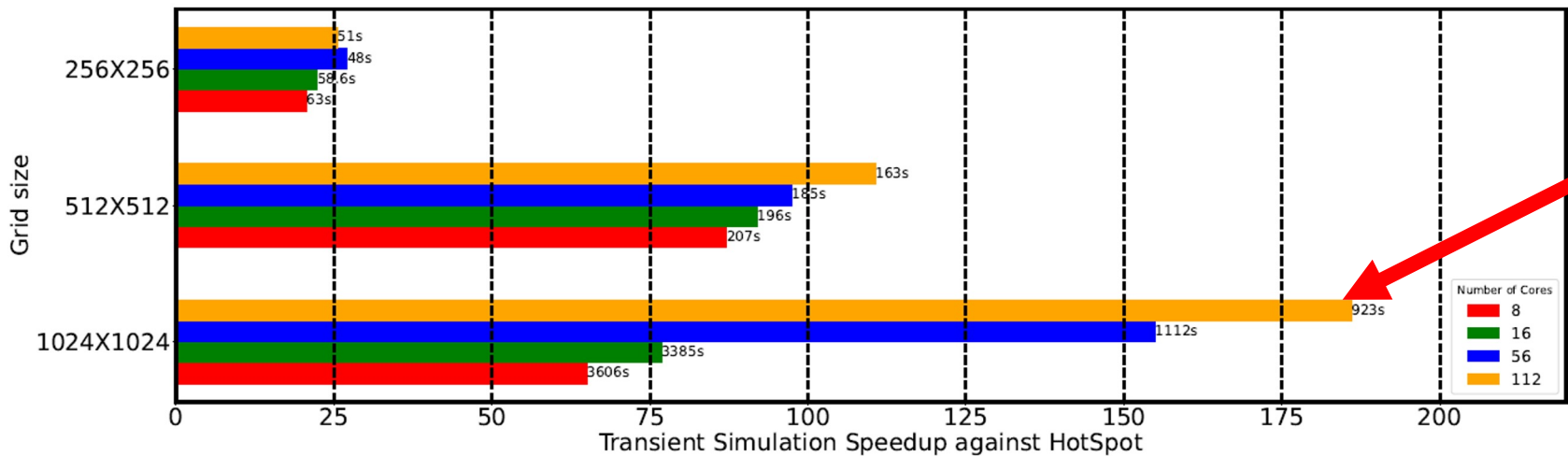
Two-Phase Vapor Chambers (VCs) with Micropillar Wick Evaporators



PACT Speed Analysis against HotSpot



1.83X speedup

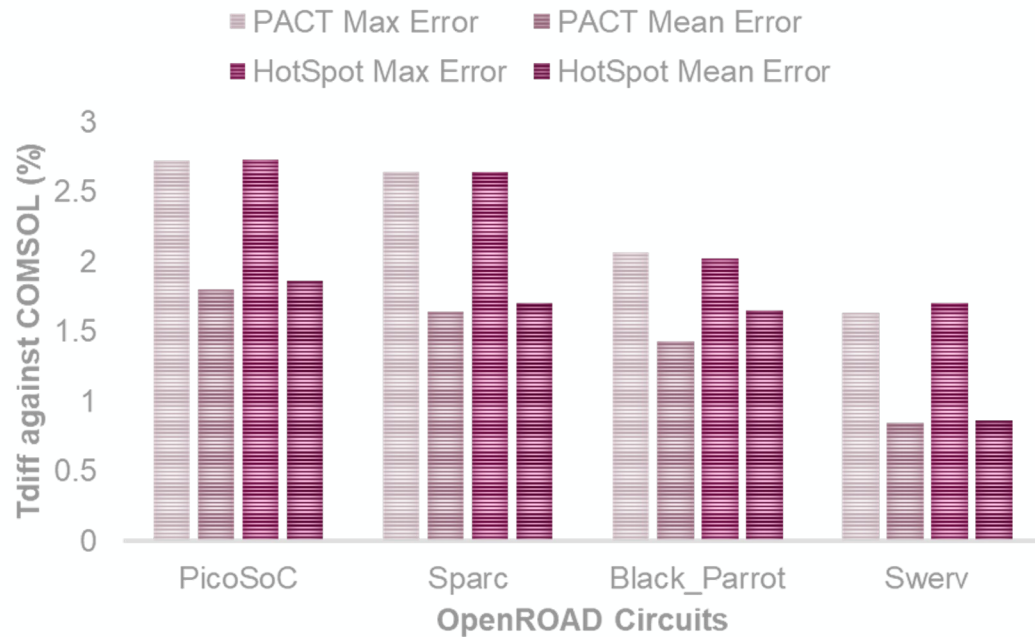


186X speedup



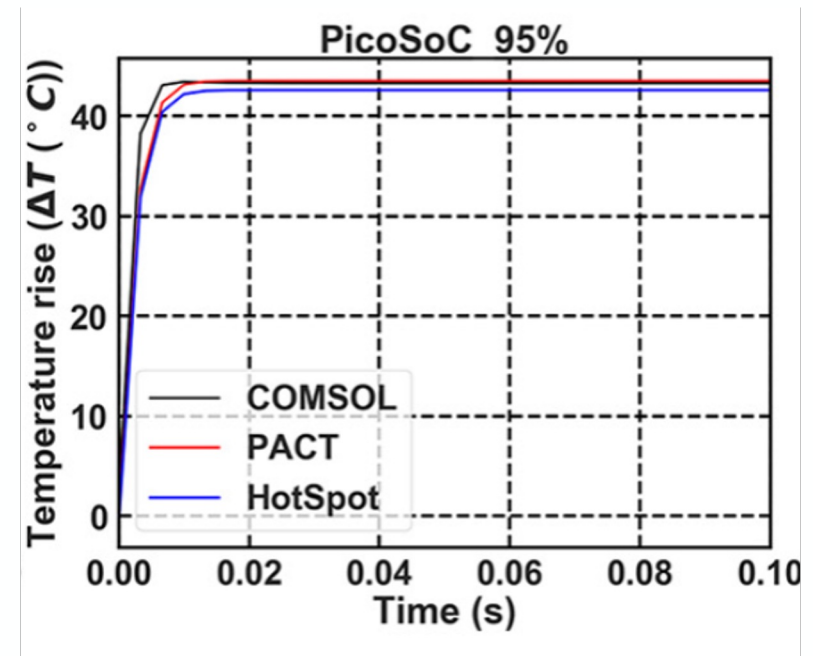
Validation with OpenROAD Benchmarks

Steady-State vs. HotSpot



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

Transient vs. HotSpot

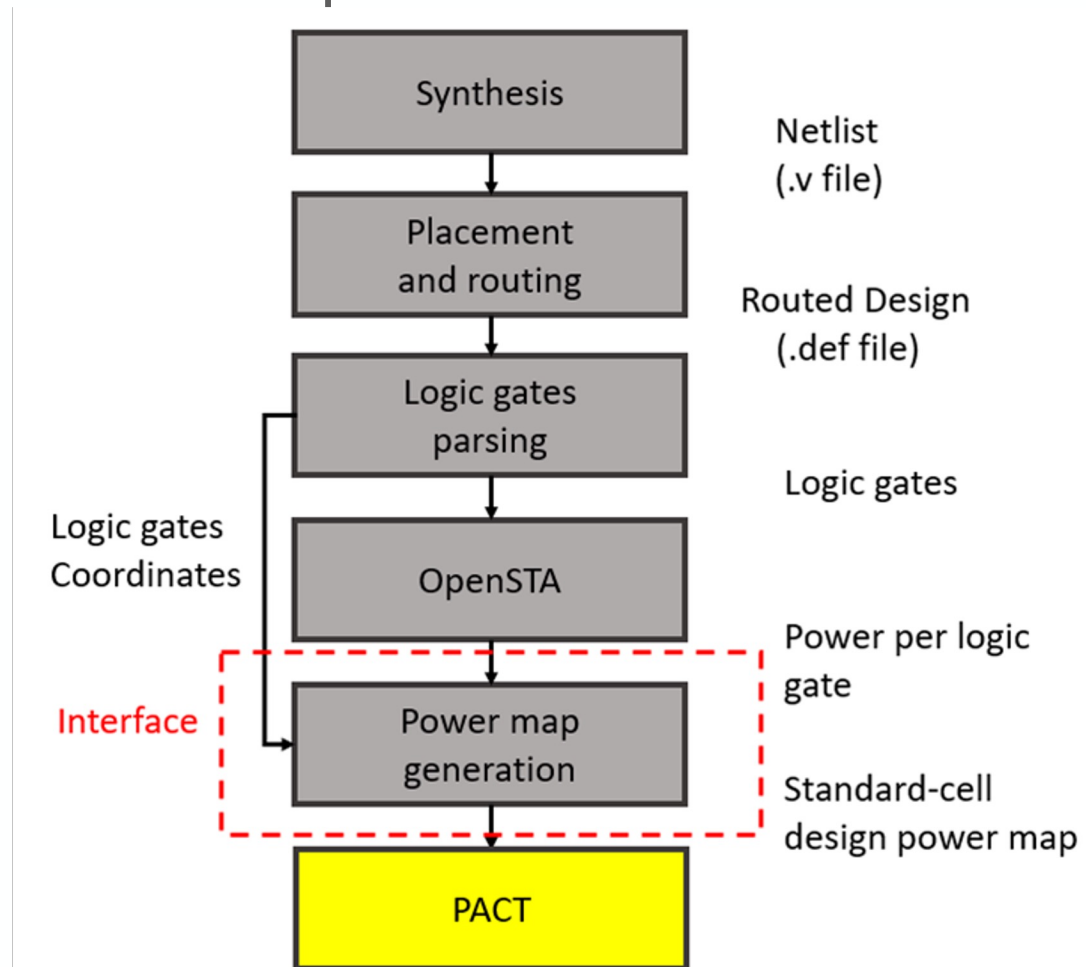


PACT vs. COMSOL (Max Transient Diff: **3.28%**)



OpenROAD Interface

OpenROAD Interface



Containerized PACT

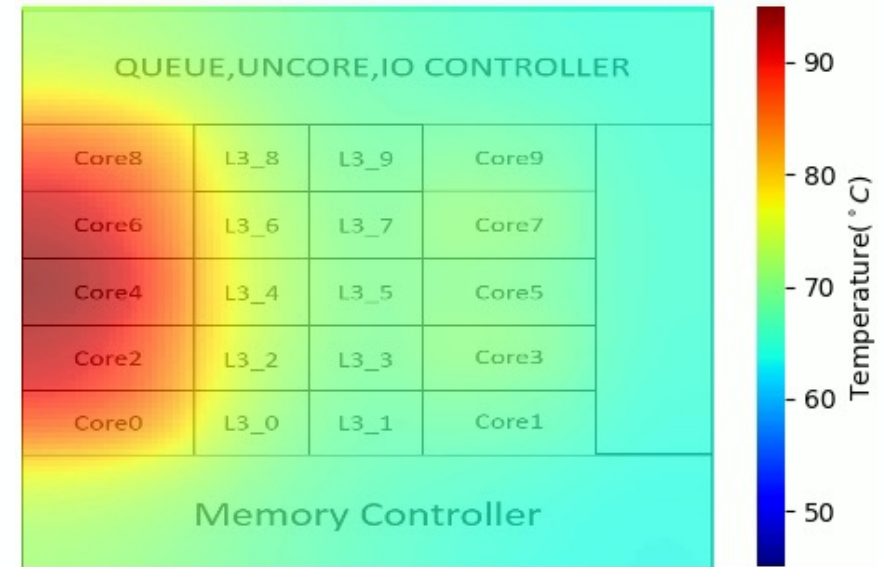
The screenshot shows a VMware Workstation 17 Player window titled "Ubuntu 64-bit - VMware Workstation 17 Player (Non-commercial use only)". Inside the VM, the Ubuntu desktop environment is visible. On the left, the Dash contains icons for Firefox, Files, and the terminal. The Files application is open to the "Home / Desktop / PACT" directory, displaying a grid of folders and files: Example, Example_command_line, HybridWick, image, Input, Liquid, M3D, MicroWick, OpenRoad, SCC, VisualPACT, Dockerfile, DownloadML.py, _init_.py, LICENSE, reconfig.sh, reconfig_parallel.sh, requirements.txt, and setenv.sh. A web browser window is open to the GitHub repository for "peaclab/PACT". The repository page shows a list of files and their commit history, including .DS_Store, .dockerignore, .gitignore, Dockerfile, DownloadML.py, LICENSE, README.md, _init_.py, reconfig.sh, reconfig_parallel.sh, requirements.txt, and setenv.sh. The README section is visible, titled "PACT: A Standard Cell Level to Architectural Level Parallel Compact Thermal Simulator". The introduction text states: "PACT is a SPICE-based PARallel Compact Thermal simulator (PACT) that enables fast and accurate standard cell level to architecture level steady state and transient parallel".



VisualPACT

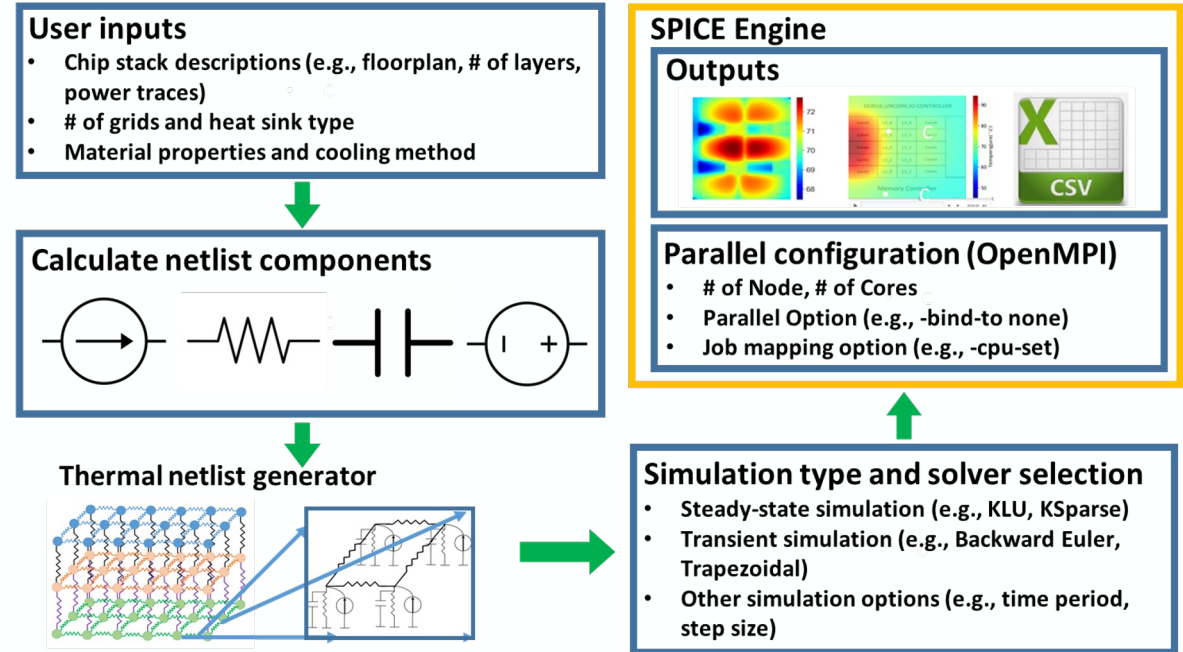
- VisualPACT
 - Generating thermal videos for transient thermal simulations
 - Visualizing transient thermal behaviors of architectural simulations

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>