OPENROAD:
FOUNDATIONS AND REALIZATION OF OPEN, ACCESSIBLE DESIGN
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THE CRISIS OF HARDWARE DESIGN ...

- ASIC design in advanced technologies: Huge barriers of Cost, Expertise and Risk

Image credit: A. Olofsson, keynote address, Intl. Symp. on Physical Design, March 2018
• Hardware innovators actually write code!
  • VHDL or Verilog that gets compiled into ICs

• The Real Crisis: Innovators are unable to evaluate their code in terms of SWaP and performance metrics

• Root Cause: The Crisis of Hardware Design
HOW IS ASIC DESIGN DONE TODAY?

• Very sophisticated tools with 1000’s of commands

• Tool supplier focus: performance, power, area

• Large teams of expert users, many manual steps

• Long project schedules

• Significant project risks
OPENROAD: NO HUMANS, 24 HOURS

• FOCUS: Ease of use and runtime

• Directly attack the crises of design and innovation
  • Schedule barrier: RTL-to-GDS in 24 hours
  • Expertise barrier: No-human-in-the-loop, tapeout GDS
  • Cost barrier: Open source (and runs in 24 hours)

• Unleash system innovation and design innovation
  • Enable tool customization to system, application needs
OPENROAD V2.0: WHAT'S NEW

- **Features**
  - Early SOC planner
  - Parasitic extraction and timing signoff

- **Usability**
  - Tool qualification on new technology
  - Messages and documentation
  - Enhanced GUI

- **Power-Performance-Area (PPA)**
  - Logic synthesis, placement, clock tree, timing optimization
  - 30% faster, 20% denser than v1.0
    = a technology node of improvement

- **True no-human-in-the-loop: Autotuner**
OPENROAD V2.0: REAL USAGE

- **SKY130**: 100+ tapeouts on Google-SkyWater, Efabless chipIgnite shuttle
- **GF12**: Mixed-signal SOC tapeout
- **Intel22**: Army Research Labs project in flight
- Now supporting: GF12, Intel22, GF55, TSMC65, SKY90, SKY130 and more
12NM SOC TAPE-IN: BLACKPARROT

- U. Washington RISC-V SoC
  - 1 CPU core, 360K cells, 53 macros
  - 3mm x 3mm package
- GLOBALFOUNDRIES 12LP
  - Invecas IOs
  - Arm standard cells / RAMs
- Output GDS DRC/LVS clean
  - Mentor Calibre verified
- RTL to GDS: < 5 hours

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Improvement: 43% 36% 28% 12% 8% 2%
Army Research Labs
GF55, GF12LP

U. Michigan / FASoC
GF12LP
• 100+ tapeouts in SKY130
• Google-funded shuttle
• Efabless “chipIgnite” commercial offering
  • OpenROAD = default EDA flow
A GROWING USER COMMUNITY

- Users range from novice to expert
- Applications include Trust, 3DIC, AI/ML
- Community metrics all growing
  - 2-week period
  - Git clones (downloads), visitors, views

- 13,960 Clones
- 7,593 Views
OPENROAD AVAILABILITY

• The Project on GitHub
  • https://github.com/The-OpenROAD-Project

• The Flow, developed by internal design advisors subteam
  • Automated full flow, built using tool components that are created for automation
  • https://github.com/The-OpenROAD-Project/OpenROAD-flow-scripts

• The Top-level Application
  • An integrated EDA tool focused on full automation
  • https://github.com/The-OpenROAD-Project/OpenROAD
NEXT: OPENROAD IN ACTION

• Design insight
• Timing debug
• Algorithm design and visualization
• Delivery of manufacturable layout

Architecture, integration and UI of a full-fledged EDA tool
DESIGN INSIGHT

TIMING DEBUG

ALGORITHM DESIGN AND VISUALIZATION

MANUFACTURABLE LAYOUT
MANY BREAKTHROUGHS

- 12nm tapeout-proven tool from an academic research effort
- Integrated architecture, database, timing engine
- OpenROAD v2.0
  - Improved performance, power-efficiency, area
    ~1 technology node improvement of frequency, density
  - Machine learning and autotuning
    No-humans, 24-hours, DRC clean – with better results
- 100+ user tapeouts from 130nm down to 12nm
- Engaged contributors: IBM, Google, DOD …

A foundation for research, innovation, and transitions
Growing a sustainable business + research ecosystem
- Businesses will productize, distribute, support
- Research ecosystem will innovate – faster
- Special application, system needs will be better served

Growing the technology
- Machine learning → intelligence and self-adaptation
- Cloud deployment → scale-up of both efficiency and quality

Growing the user and developer community
- Looking for DOD, DIB to join and guide this effort
FACULTY, INDUSTRY, EDA VETERANS

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