OpenROAD

Foundations and Realization of Open, Accessible Design

Andrew B. Kahng, UCSD
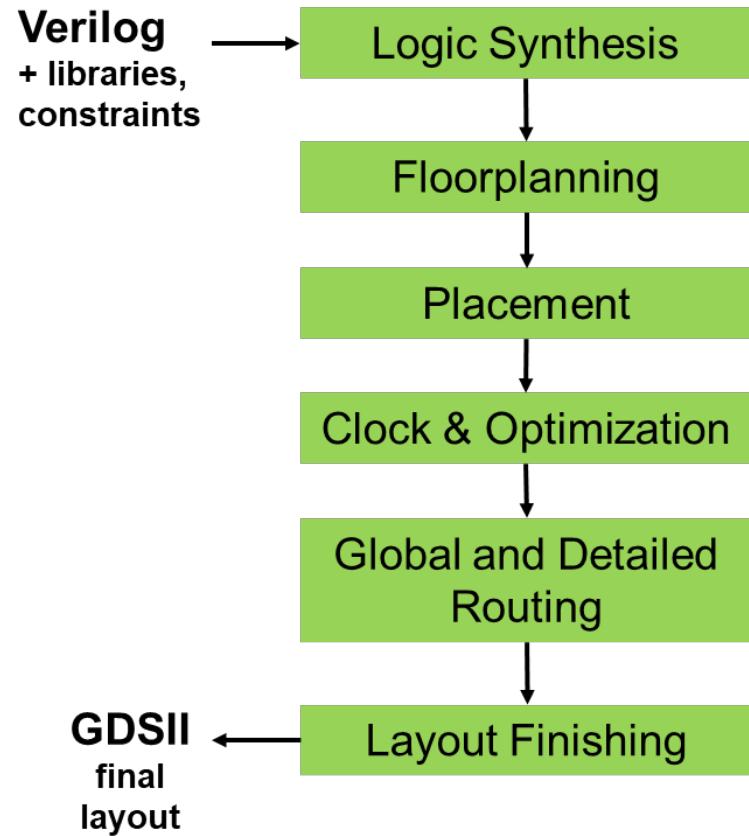
abk-openroad@ucsd.edu
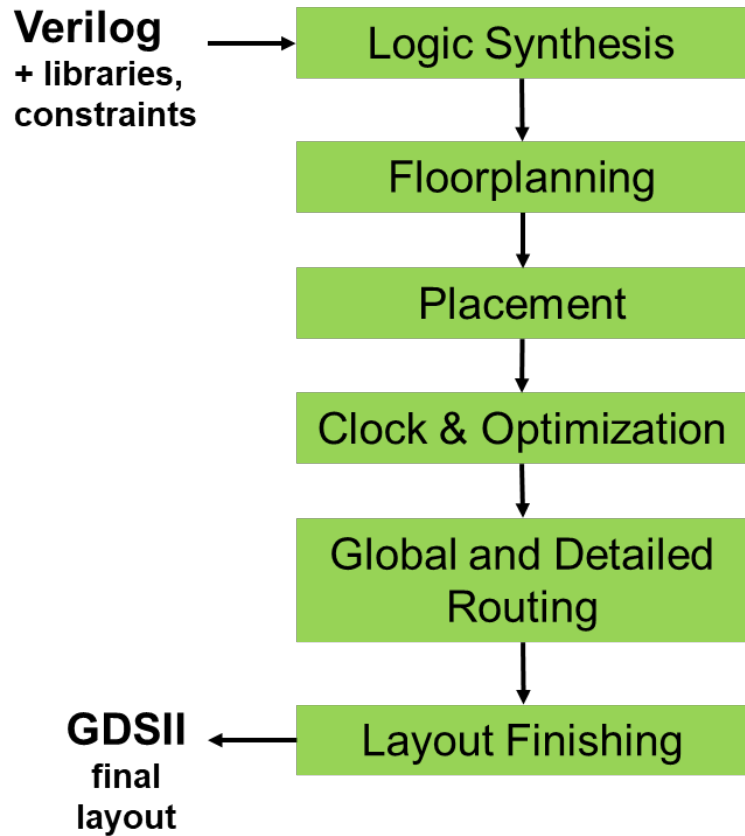
https://theopenroadproject.org

https://github.com/The-OpenROAD-Project

OpenROAD

Verilog
+ libraries,
constraints

```
┌─────────────────────────┐
│     Logic Synthesis     │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│      Floorplanning      │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│        Placement        │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│   Clock & Optimization  │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│   Global and Detailed   │
│         Routing         │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│     Layout Finishing    │
└─────────────────────────┘
```

GDSII
final
layout

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→ Logic Synthesis

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- **Functionality:** 600+ tapeouts, 130-12nm
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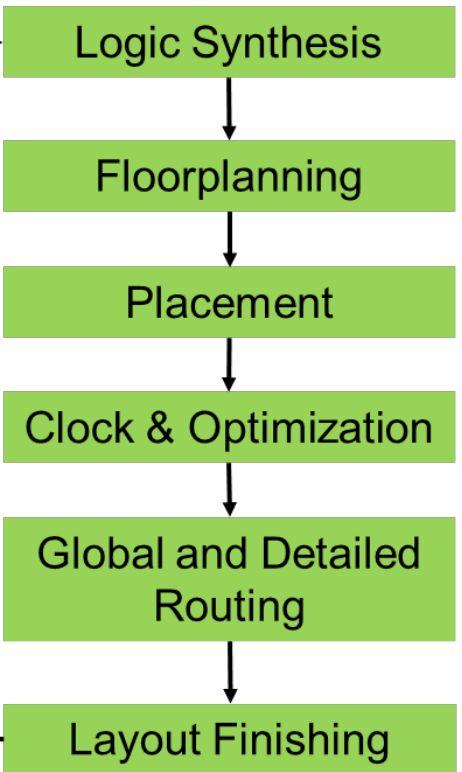- **Education and Workforce:** from high school to graduate level, extension

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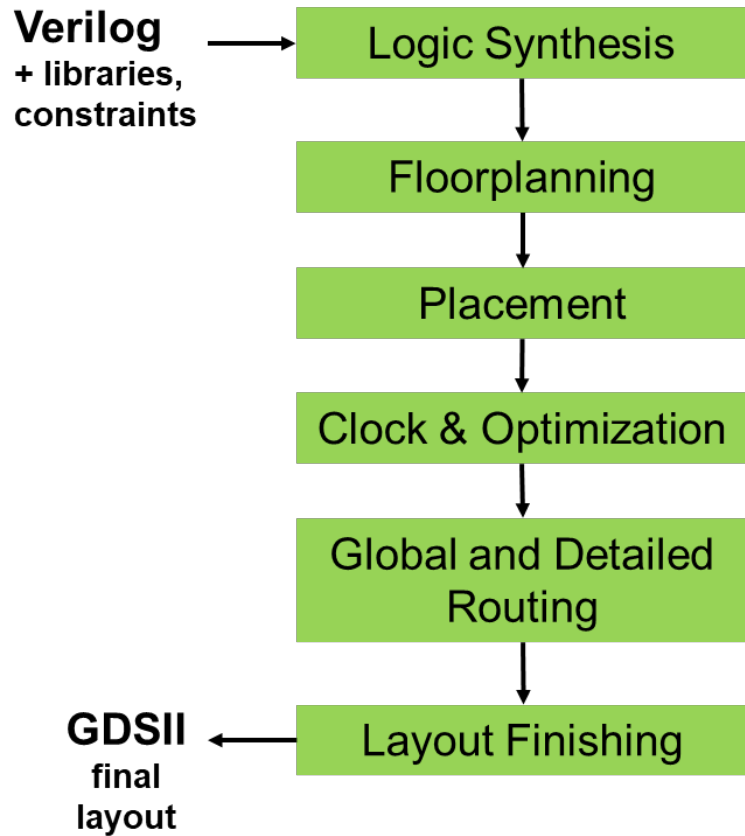- Layout Finishing

→ **GDSII** final layout

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- **Small R&D teams, startups**

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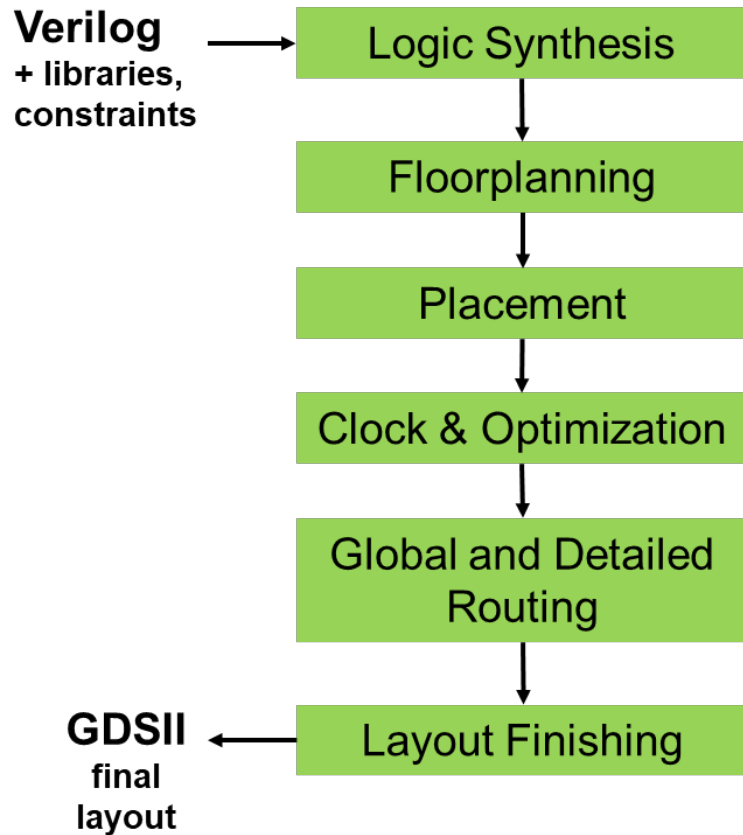

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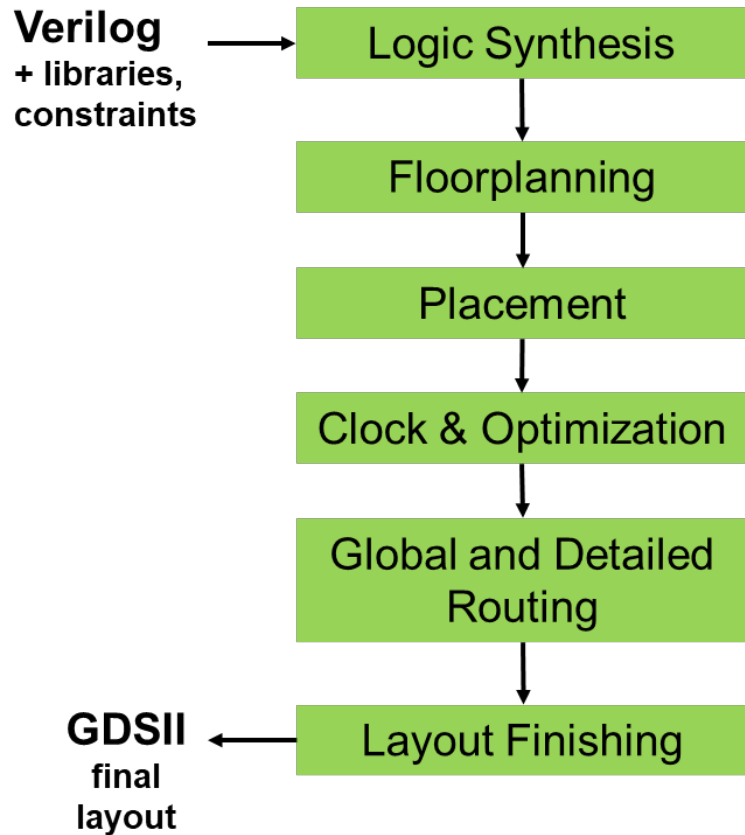- **Small R&D teams, startups**

Directions:

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Directions: Cloud, ML

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  "COPILOT" = **C**loud **O**ptimized **P**hysical **I**mplementation using OpenROAD **T**echnology

- **ML challenge: predict failure and intervene**

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- **ML challenge: predict failure and intervene**

- **+ low-hanging fruits such as AutoTuner**

Default flow score = 1,174,346
Our Best Score = 855,373
(370 trials in total 500 #trials)
(less is better)
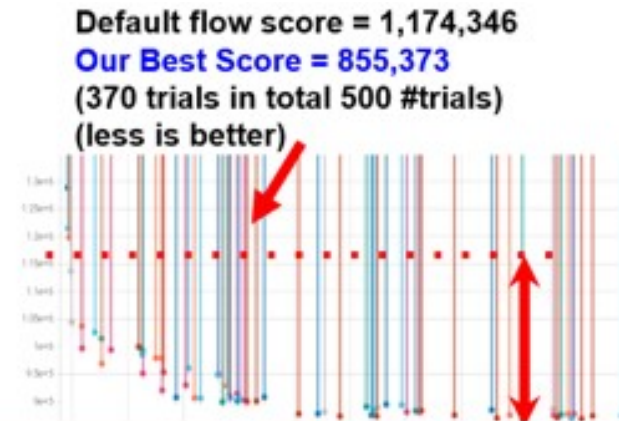
Improvement
WL 1003801um → 843258um **(-16%)**
Effective CP 20.935ns → 16.185 ns **(-23%)**
Total power 0.024 W→ 0.0133 W **(-45%)**
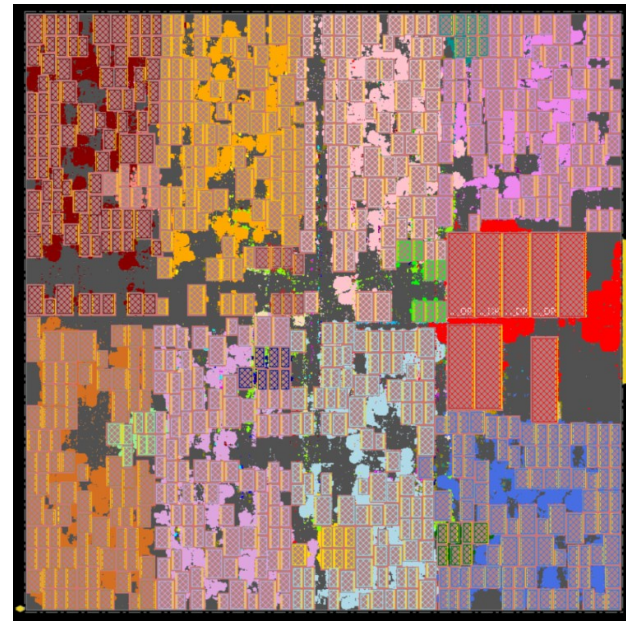
Directions: Early Design Space Exploration

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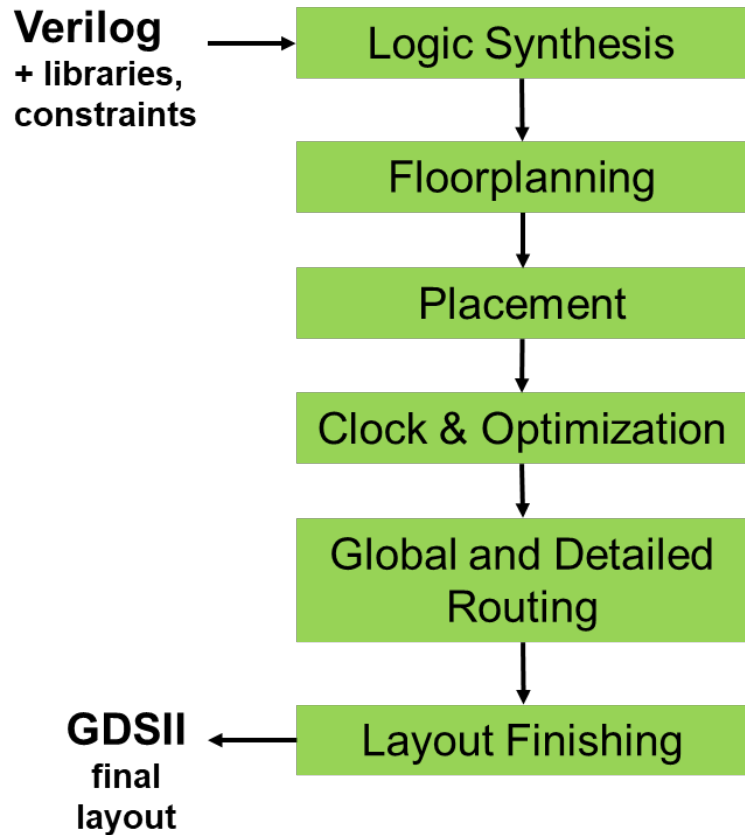
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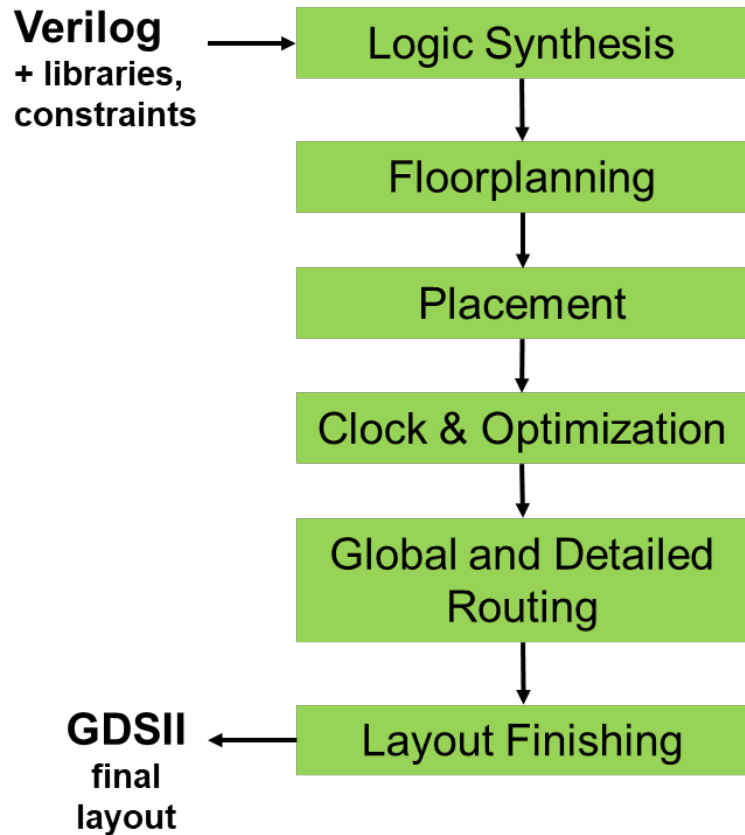
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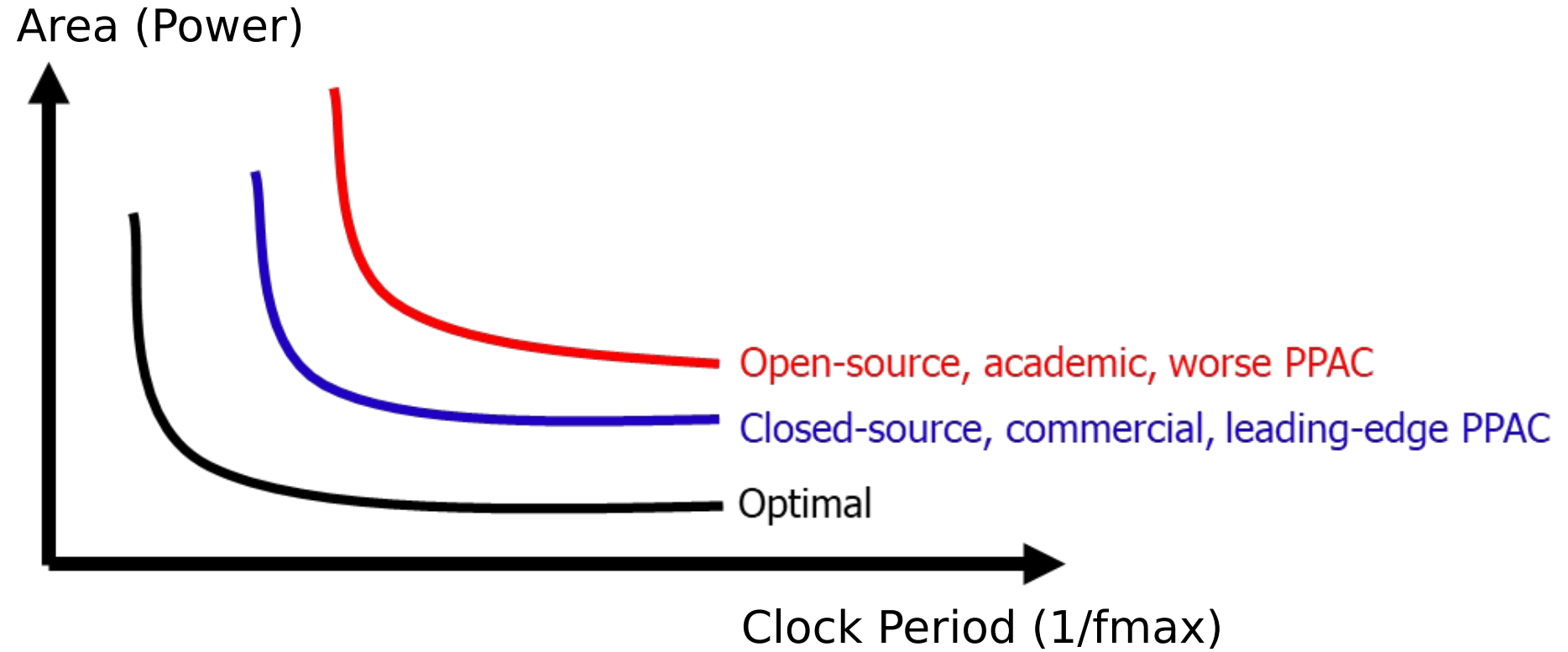
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- **Hier-RTLMP: /src/mpl2**
  - **RTL and dataflow-driven, human expert-like**

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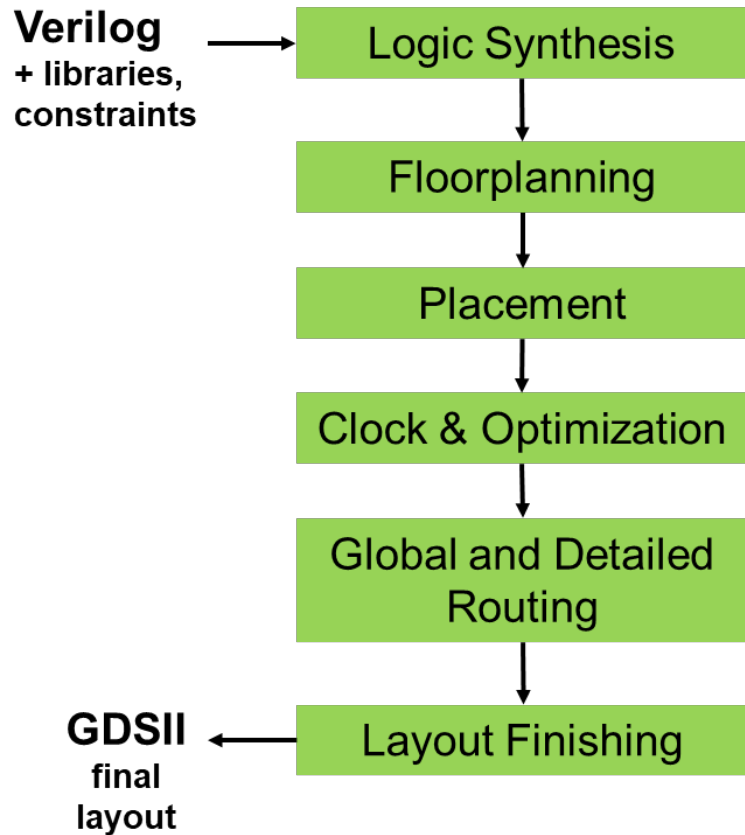
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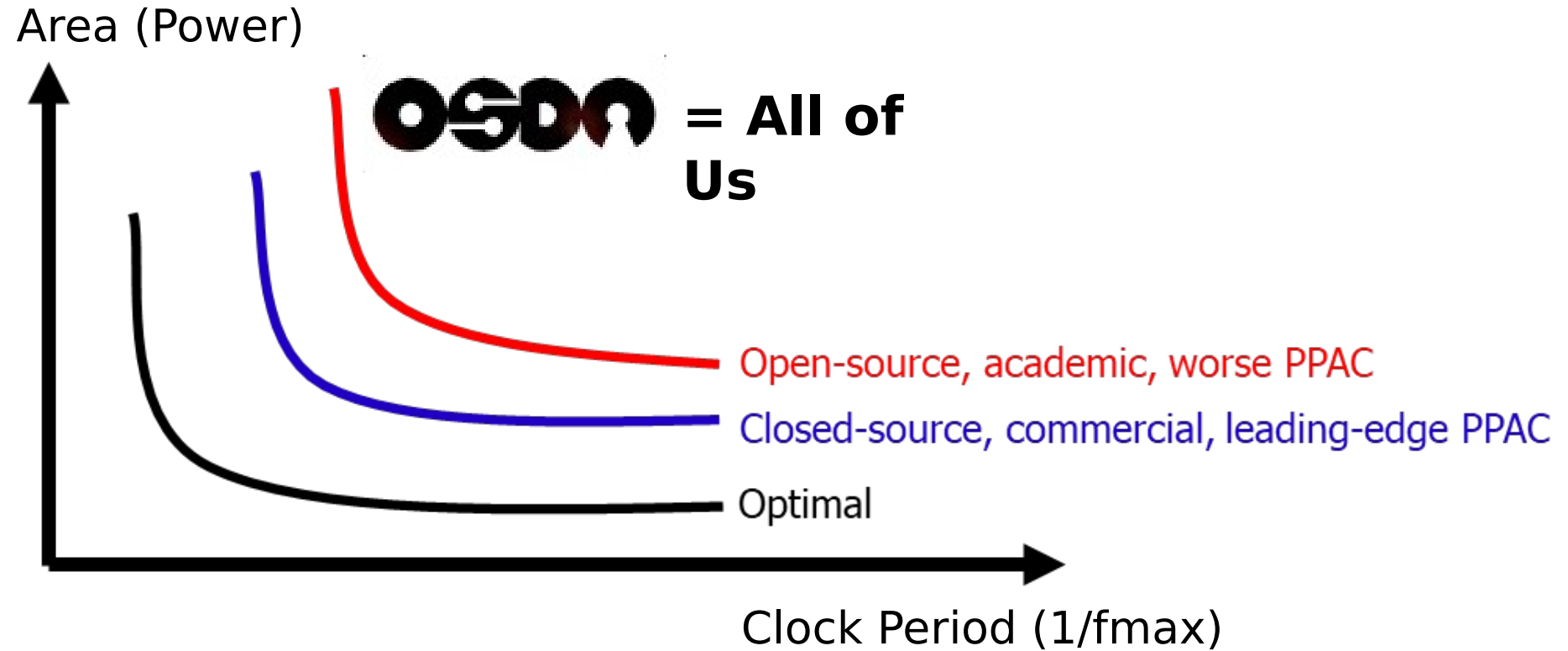 - **RTL and dataflow-driven, human expert-like**
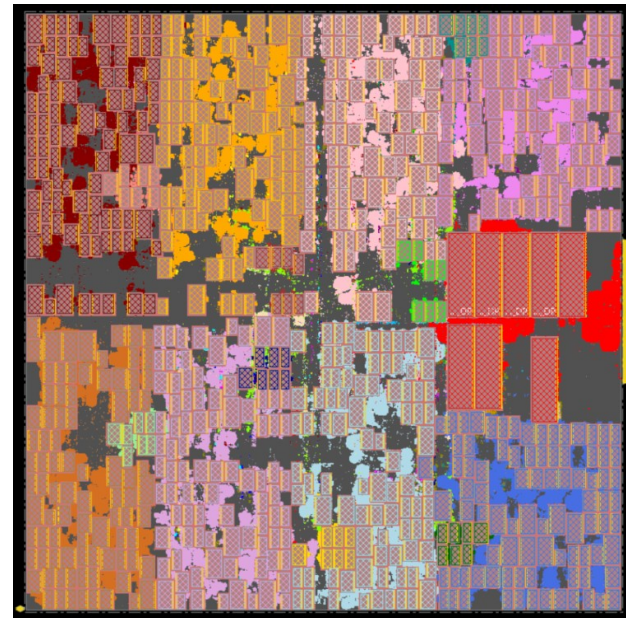
- **TritonPart: /src/par**
  - **Timing- and constraint-driven partitioner**
  - **Displaces hMETIS, KaHyPar**
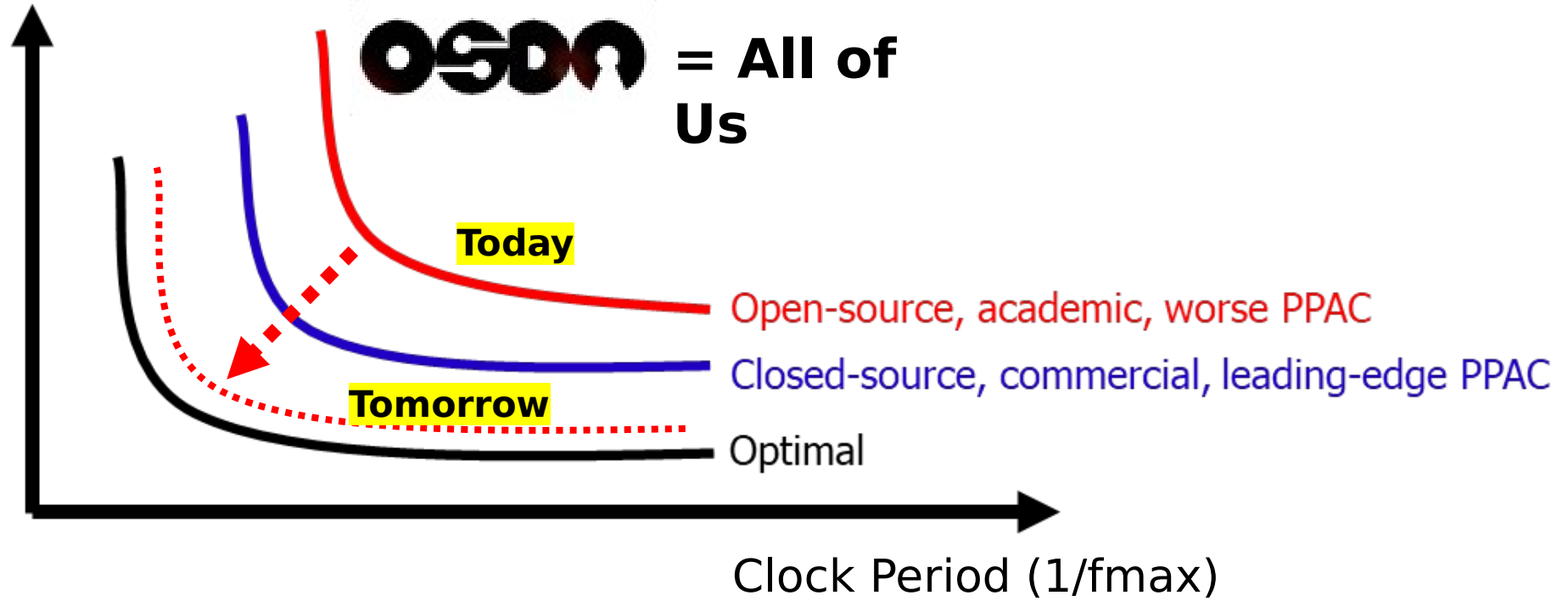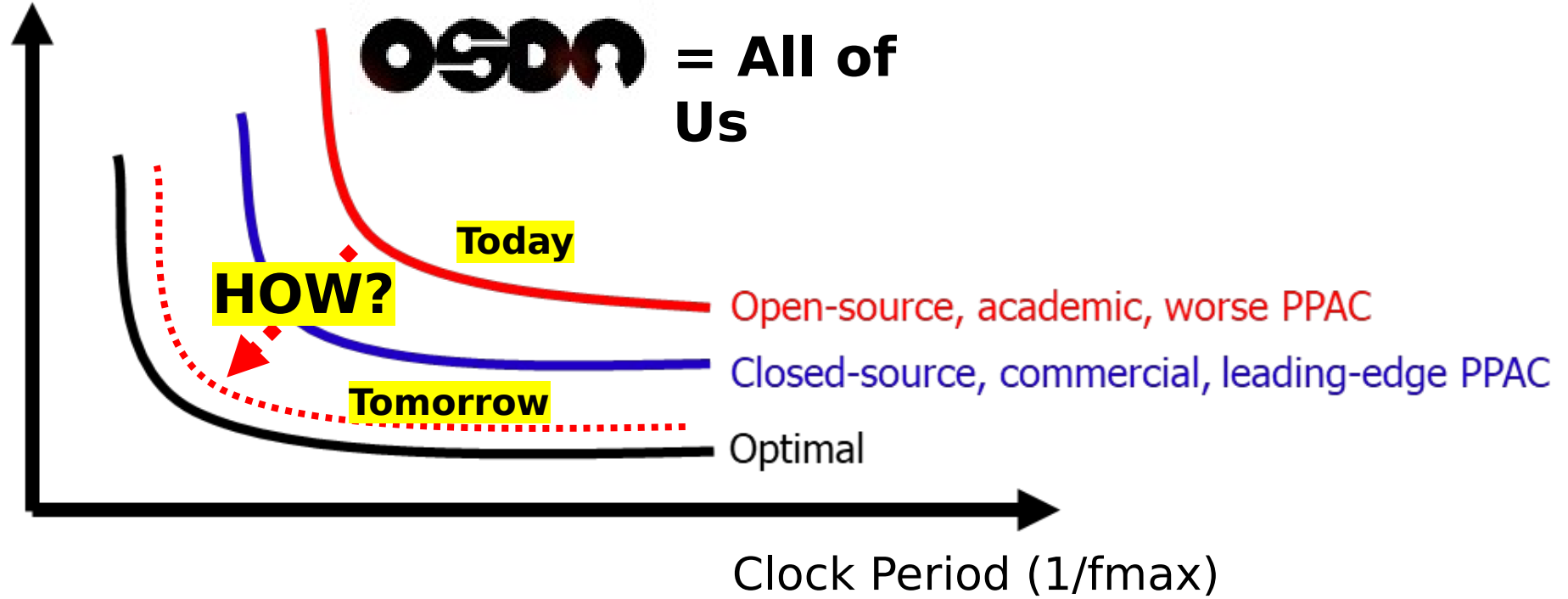
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OSDA Directions

Area (Power)

Open-source, academic, worse PPAC

Closed-source, commercial, leading-edge PPAC

Optimal

Clock Period (1/fmax)

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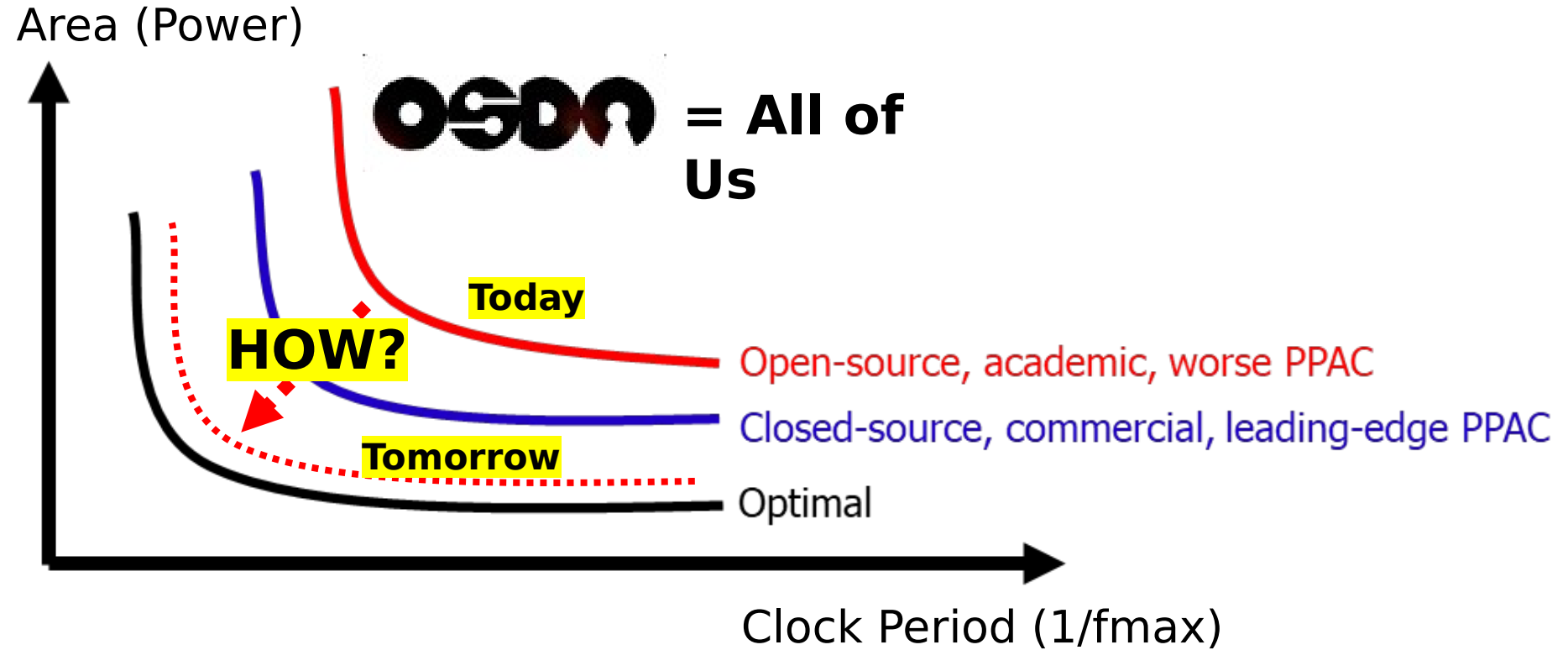
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Efficiency … as a Community!

Thought #1: Bars Matter

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  - Relevance (functionality, data, quality of results)
    - Foundry N5 vs. ASAP7 / ASAP5
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"more wood behind fewer arrows" ?

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  - **METRICS2.1**
  - **OpenROAD**
  - **…**

  "roadbed for the road ahead"

A road starts with a roadbed

At the nexus of learning, optimization, and CAD, several foundational elements provide a "roadbed" for the road ahead. These include: 1) benchmarking and roadmapping of CAD/EDA optimizations; 2) data to enable data-driven methods; and 3) "EDA 2.0" that broadly reinvents core optimization algorithms and tool architectures for scalability on modern compute substrates.

doi:10.1109/MDAT.2022.3161593

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"A journey of a thousand miles begins with a single step"
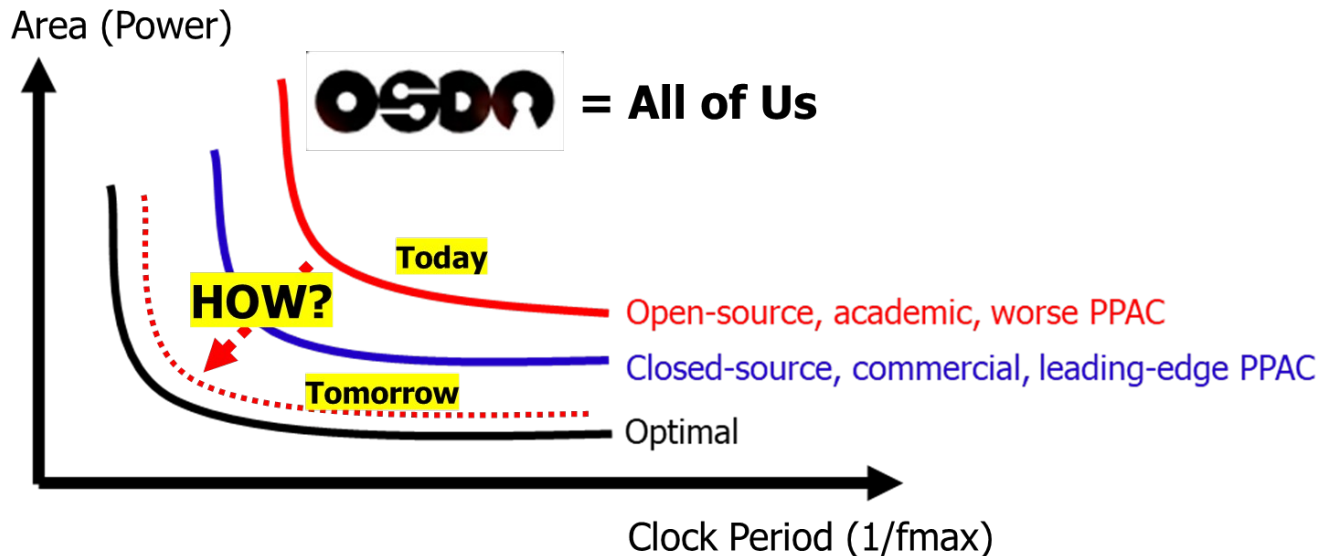
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Some Links

- "Leveling Up: A Trajectory of OpenROAD, TILOS and Beyond", *Proc. ISPD,* March 2022. .pdf .pptx

- "Our Real Scaling Challenge: People", ACCESS-CEDA seminar, Sept. 2022. .pptx

- "Bars and Barriers to Overcome for Shared ML EDA Infrastructure", NSF Workshop on Shared Infrastructure for Machine Learning EDA, March 2023. .pptx

- Thoughts on open source in EDA
  - 2002: "Toward CAD-IP Reuse: The MARCO GSRC Bookshelf of Fundamental CAD Algorithms" [.pdf] (also: [.pdf])
  - 2019: "Looking Into the Mirror of Open Source" [.pdf]
  - 2020: "Open-Source EDA: If We Build It, Who Will Come?" [.pdf]
  - 2021: "The OpenROAD Project: Unleashing Hardware Innovation" [.pdf]
  - 2022: "The OpenROAD Project: A Foundation for Research and Education in EDA and IC Design" [.pptx]
  - 2022: A. B. Kahng, "A Mixed Open-Source and Proprietary EDA Commons for Education and Prototyping", [.pdf] [.pptx]

- "https://theopenroadproject.org and https://github.com/The-OpenROAD-Project

THANK YOU !