

# Value and Opportunities in Open-Source for Circuit Design



Christoph Sandner, Senior Principal  
Infineon Technologies Austria AG  
[Christoph.sandner@Infineon.com](mailto:Christoph.sandner@Infineon.com)

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- Motivation for OS Hardware
- Relevant pillars:
  1. Education
  2. OS PDKs
  3. OS IP
  4. Disruptive Methods: (Analog Design) Automation

To get Industry involved, OS has to provide value!!!

# Why Hardware Collaboration?

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## 🌀 **Create Culture**

- Emulate software success in hardware

## 🌀 **Coopetition**

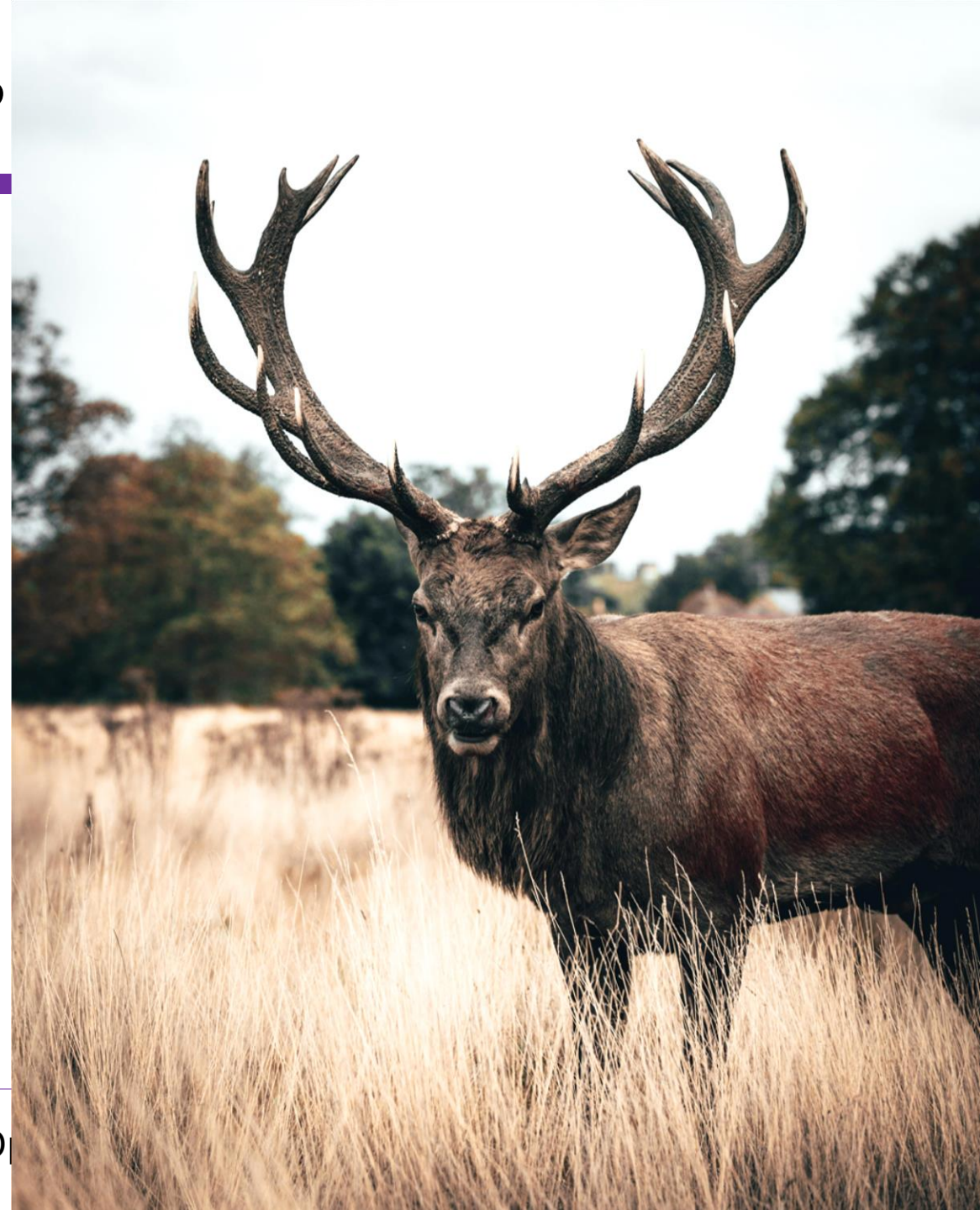
- Value is interdependent on competitors

## 🌀 **Enlightened Self-Interest**

- Innovation requires diverse ideas

**Game Theory:** Stag Hunt – Work together towards mutual benefit, rather than solving small problems on our own.

[S. Cetola, Intel]



# The Problem

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## □ Workforce / Education:

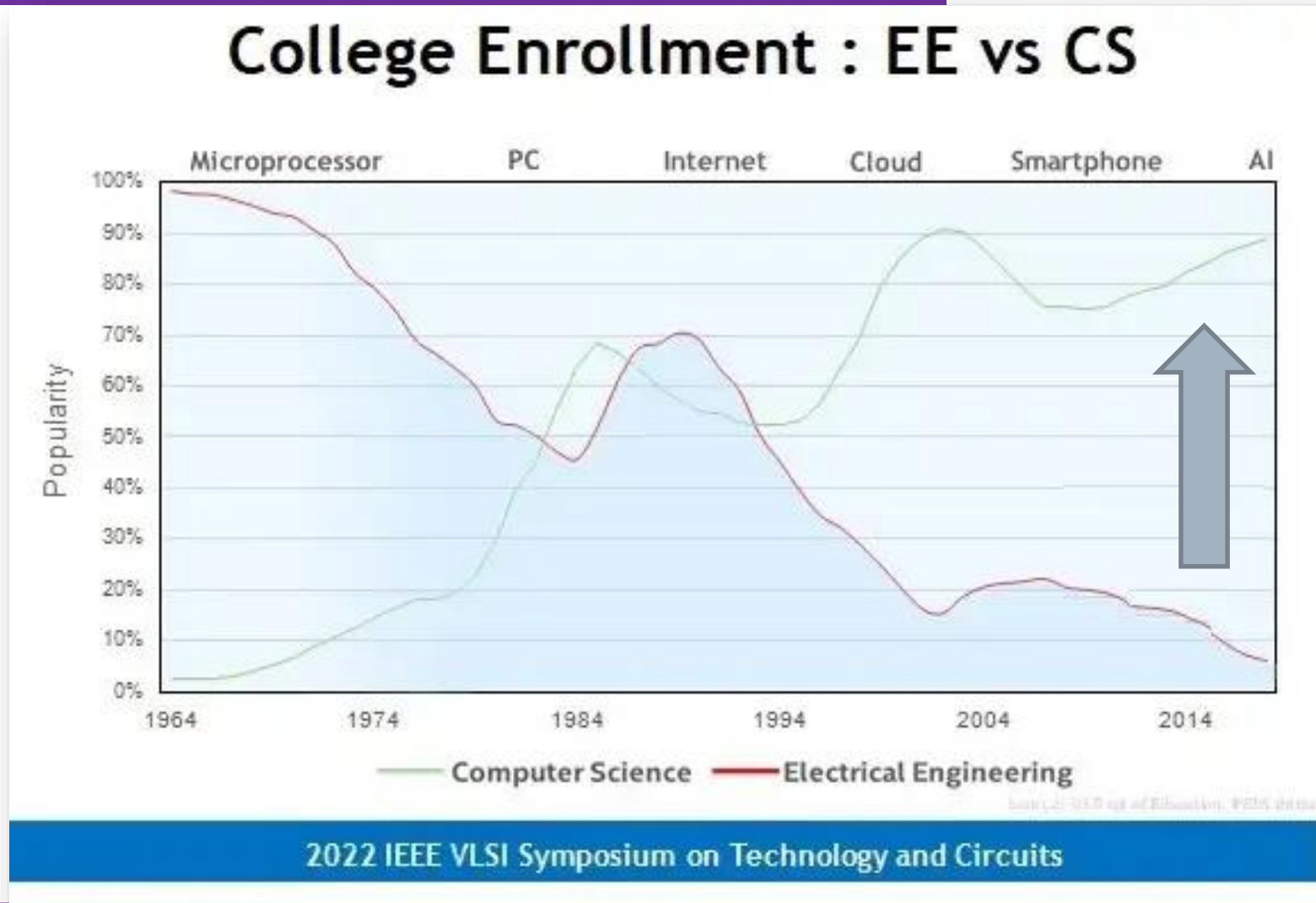
- Lack of skilled EE resources
- Computer Science (CS) is more attractive
- EE is a complex topic to learn, no abstraction
- Barrier to get hands-on experience (do a chip tapeout) is very high

## □ R&D Efficiency, Time-To-Market:

- Industry competes on maximizing EBIT
- Complexity and effort of chip development increases by 2...4x for every node
- Analog IC design: Still many manual steps, lack of automation



# Semiconductor Industry will die out...



or...



# The Solution

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Academia and Industry need to join forces!  
Open-Source to the rescue?



# OS Success Story:



- Free and OS Instruction Set Architecture (ISA)

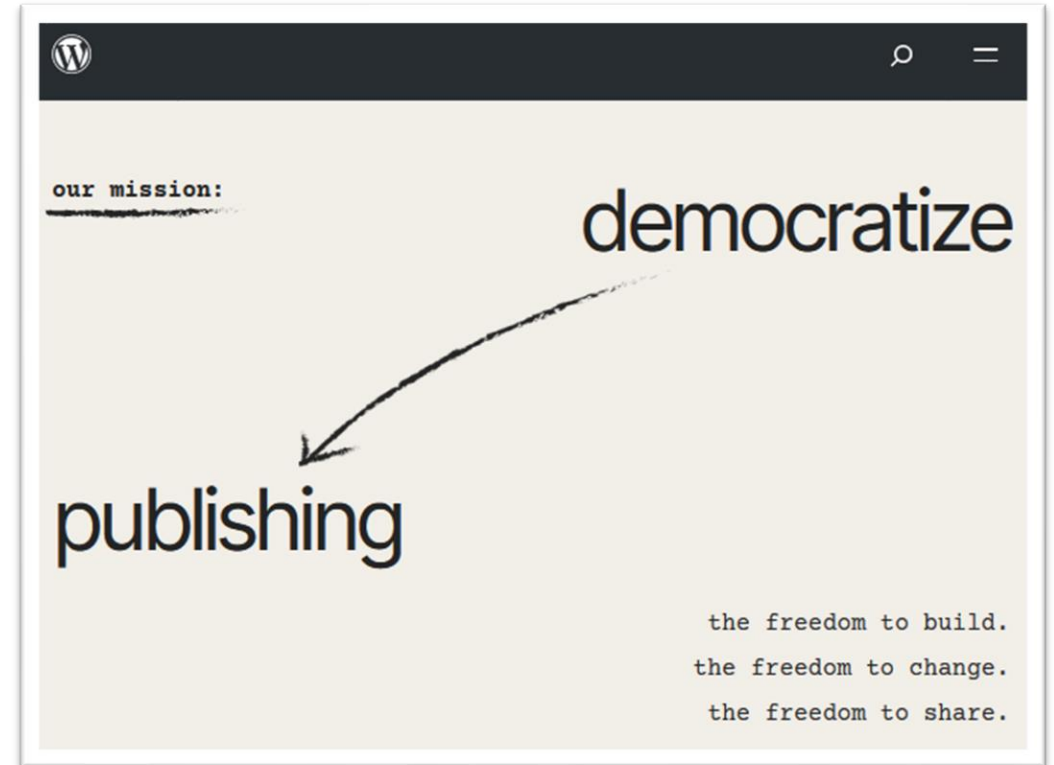
Barriers	Legacy ISA	RISC-V ISA
Complexity	1500+ base instructions Incremental ISA	47 base instructions Modular ISA
Design freedom	\$\$\$ - Limited	Free - Unlimited
License and Royalty fees	\$\$\$	Free
Design ecosystem	Moderate	Growing rapidly. Numerous extensions, open and proprietary cores
Software ecosystem	Extensive	Growing rapidly

**Market 2021: \$445 million**  
**CAGR >30% until 2027**  
**Growing design ecosystem**  
**both open and proprietary**

[Redmond, 2021][<https://www.bccresearch.com>]

# OS Success Story: Wordpress

- ❑ WordPress powers 43% of websites
- ❑ Endless variety of plugins  
→ Huge ecosystem
- ❑ Low entry hurdle
- ❑ Everyone can design and maintain a small website



- ❑ Why not... “Democratizing IC Design”? © Boris Murmann



# OS to the Rescue? - Education

/ Home / About / Solid-State Circuits Directions / SSCS PICO Program

## SSCS PICO Program

### Democratizing IC Design: The SSCS PICO Program



The Solid-State Circuits Society is committed to improving the state of IC design and accessibility in integrated circuit (IC) design. We envision a future in which chips can be designed through a web browser, by anyone, anywhere and through open worldwide collaboration.

...chips can be designed through a web browser, by anyone...  
...help to accelerate the construction of the required ecosystem

Outreach (PICO) program, the SSCS is working with the rapidly growing open-source community to help accelerate the construction of the required ecosystem. Our goal is to help build and connect to new communities that share our excitement about IC innovation and its democratization toward a new wave of global impact.

# OS to the Rescue? - Education

<https://bit.ly/esscxrc22-goog>

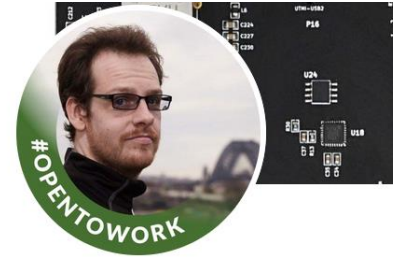
- Google, ESSICR2022:
- Don't need to wait for your masters course to start with IC design...
- Do your first tapeout in school!

## Future pathway for ASIC designer

Tape out	Student Level	Budget (USD)	Process Node
<b>First</b>	Middle School	<\$20	180nm / 130nm
<b>Second</b>	High School	\$20 → \$1,000	180nm → 90nm
<b>Multiple</b>	Undergrad	\$100 → \$10,000	90nm → 45nm
<b>Advanced</b>	Masters	>\$10,000	90nm → 22nm
<b>Leading Edge</b>	PhD	>\$50,000	<28nm 7nm / 5nm / 3nm

# OS to the Rescue? – PDKs

- 2020: SkyWater 130nm CMOS
  - <https://github.com/google/skywater-pdk>
- 2022: GlobalFoundries 180nm MCU
  - <https://github.com/google/gf180mcu-pdk>
- 2023: IHP 130nm BiCMOS
  - <https://github.com/IHP-GmbH/IHP-Open-PDK>
- 2024: ?
  
- Permissive Apache 2.0 licensing

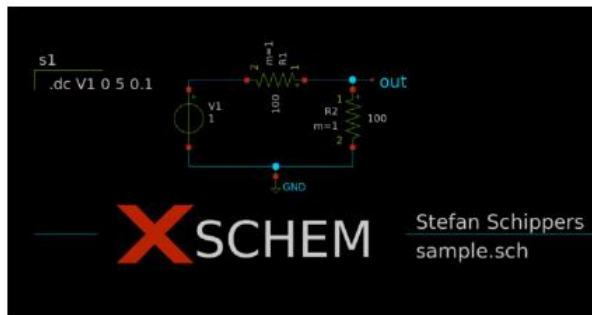
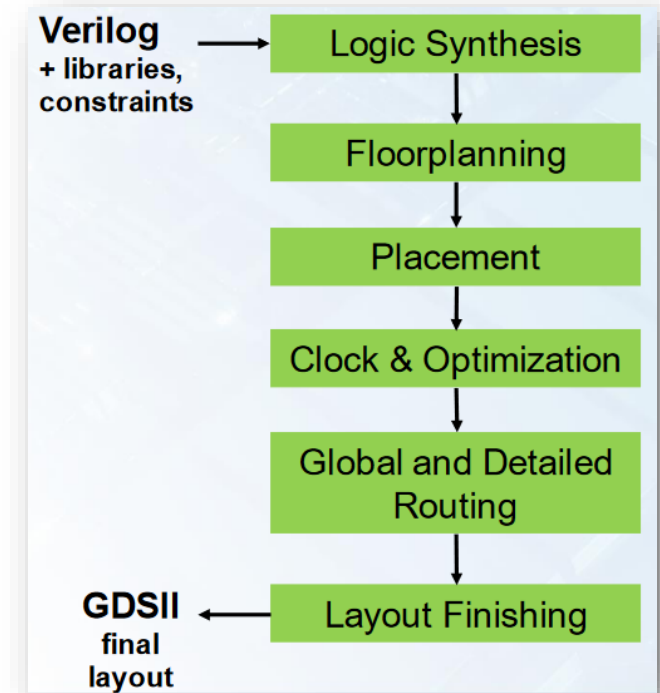


Tim (mithro) Ansell ✓



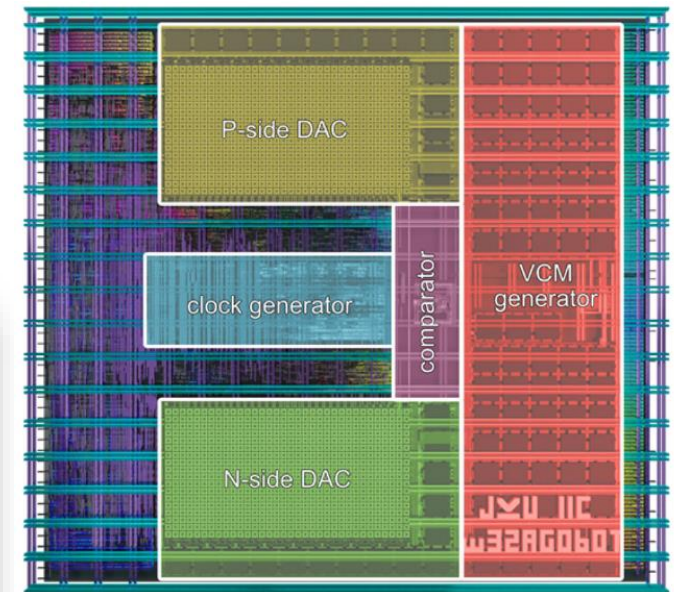
# OS to the Rescue? – Design System

- Growing number of OS design systems, eg:
  - [OpenRoad](#), [OpenFASOC](#), [Chipyard](#), [BAG](#), [Align](#), [Magic](#), [OpenRAM](#), ...
- Growing ecosystem:
  - [efabless](#), [ZeroAsic](#), [Antmicro](#), [TinyTapeout](#), ...



# OS to the Rescue? – IP Design

- ❑ Self-clocked 12-bit non-binary fully differential SAR-ADC
- ❑ Using SKY130 open-source PDK
- ❑ Entire mixed-signal circuit design and layout were created with free and open-source software
- ❑ Performance comparable to similar ADCs



Harald Pretl • 1st

Full Professor (IC Design) @ JKU, Visiting Researcher @ IHP, fou...

6d • 🌐

Our paper (open access) describing a fully open-sourced SAR ADC IP (with fully, I mean every design file, etc., on GitHub, link in the paper) using an open-source toolchain (link in the paper) just came out. It is a nice summary and quick read; everyone who craves full detail should consult the master thesis of [Manuel Moser](#) (link in the paper).

<https://link.springer.com/article/10.1007/s00502-023-01195-5>

# OS to the Rescue? - Automation

- Can OS help to find our holy grail “Analog Circuit Synthesis” ?
  - Today, no widely adopted solution for analog automation
  - Lots of research at different institutions, but no clear winner
  - Would need a common “condensation nucleus”

...better join forces?



[Alon, ESSCIRC'21]

# Why OS - Enablers

## □ **People!**

- OS community often fueled by individuals
- Companies step in if they see value
- Mindset change in Hardware Industry needed:  
See OS as opportunity, not as a threat!

## □ **Money!**

- New Government funding requires OS: Darpa, Chips Act, Germany, ...
- Seed funding, eg. shuttle runs

## □ **Collaborate!**

- Foundations, like ChipsAlliance, OpenHWgroup
- Need common ground for “standardized” APIs



# Democratizing IC Design!

- Our own first small steps...
- 2022 – Foundation of the **MOSAIC** group
  - Modular Open Source Analog IC design framework
  - Bootcamp, [Gitlab](#), [YouTube](#)
- 2023 – Infineon Summer school
  - 50+ students invited on-site to learn about analog generators

<http://www.infineon.com/schools>

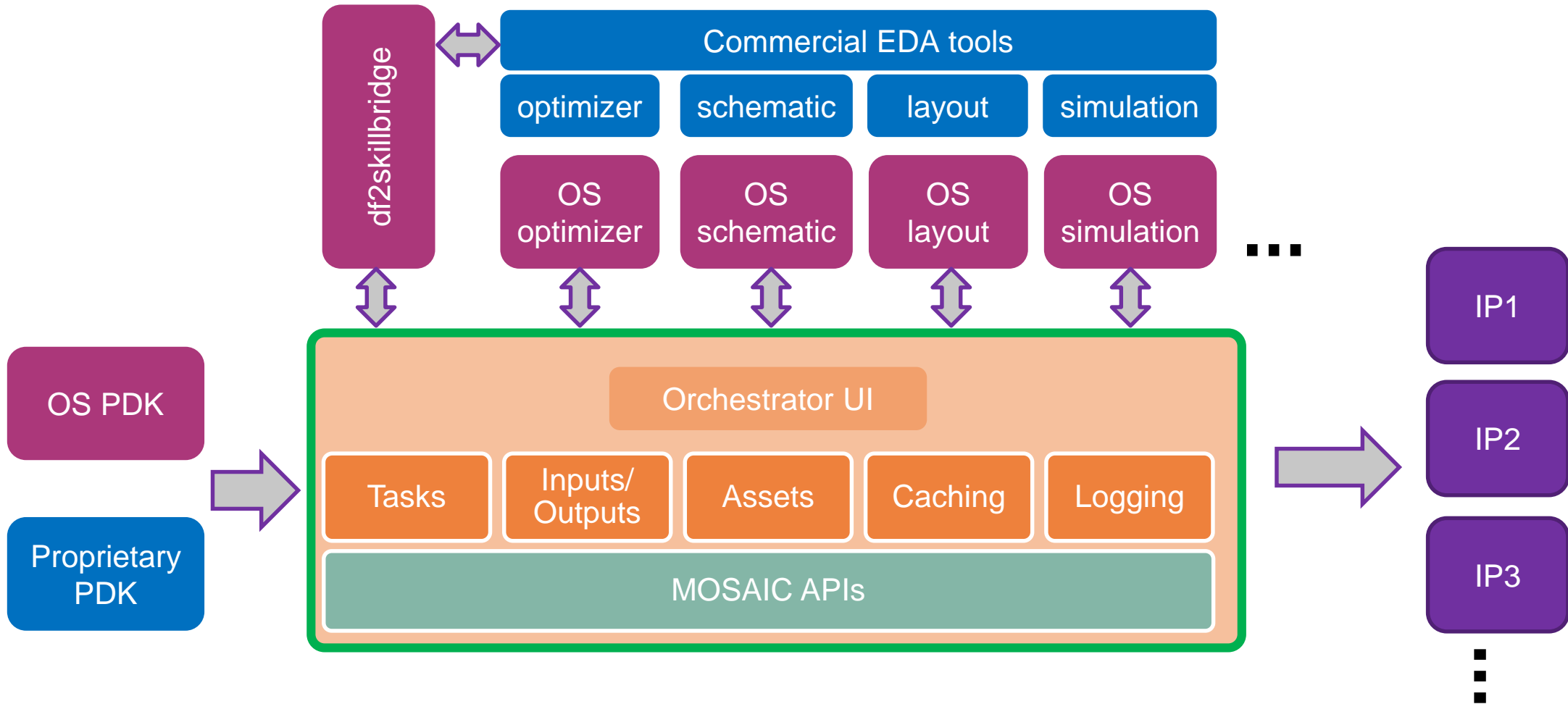


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# MOSAIC Analog Design Framework



# Why OS - Opportunities

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- EDA toolchain: Common OS framework for analog circuit synthesis
  - ...enable various tool plugins, incl. AI applications
  - ...allowing fast creation of analog IP for different specs
  - ...create a new market for analog generator IPs
- SMEs to offer value-add to OS ecosystem providing new tools/plugins
- OS PDKs: Low entry cost to design own chip
- OS will ease collaborations and lower entry barrier:
  - For teaching: OS design chain is good enough already today
  - No NDA issues, easy exchange of circuit examples
  - Get funding money

# How to get Industry into OS? Threats

- Business Risks:
  - Technical (eg. support)
  - Security
  - Patent
  - Giving away to competitors
  - Becoming dependent
- Organization:
  - Lack of OS experience
  - No OS approval process, no clear decision maker

Does your organization evaluate any particular **business risks** before allowing employees to contribute to open source projects? Check all that apply.

Technical debt

Security risk

Patent risk

Giving away technology to competitors

Becoming too dependent on technology developed by other firms

Increase likelihood of job market competition / employee turnover

None of the above

[\[https://www.linuxfoundation.org/research/surveys/open-source-software-funding-survey-2024\]](https://www.linuxfoundation.org/research/surveys/open-source-software-funding-survey-2024)

# How to get Industry into OS? Benefits

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1. Cost efficiency: No licensing fees, share development costs
2. Innovation: OS projects harness creativity and expertise of a global community
3. Flexibility: No vendor lock-in, code can be customized
4. Security, Quality: Full transparency, rapid response to vulnerabilities
5. Talent attraction: Young engineers like OS, helps to foster new skills
6. Interoperability: OS and proprietary tools can be interchanged (requirement)

By leveraging these benefits, industries can drive innovation, reduce costs, and maintain a competitive edge in a rapidly evolving technological landscape.

[partly GPT4.0]

# 2024: We continue, step by step...

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# References

...this is just an incomplete list of some interesting links to probe further:

- ❑ <https://sscs.ieee.org/about/solid-state-circuits-directions/sscs-pico-program>
- ❑ <https://open-source-eda-birds-of-a-feather.github.io/> (OS EDA session at DAC 2023)
- ❑ <https://tinytapeout.com/>
- ❑ [https://gitlab.com/mosaic\\_group/mosaic\\_BAG/virtuoso\\_template](https://gitlab.com/mosaic_group/mosaic_BAG/virtuoso_template)
- ❑ <https://www.youtube.com/@mosaic6083>
- ❑ <https://www.chipsalliance.org/>
- ❑ <https://www.openhwgroup.org/>
- ❑ <https://chipyard.readthedocs.io/en/stable/index.html>
- ❑ <https://developers.google.com/silicon>
- ❑ <https://bit.ly/esscxrc22-goog>
- ❑ <https://www.klayout.de/>
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- ❑ <https://github.com/ALIGN-analoglayout/ALIGN-public>
- ❑ <https://github.com/The-OpenROAD-Project/OpenLane>
- ❑ <https://bag3-readthedocs.readthedocs.io/en/latest/>
- ❑ <https://niftylab.github.io/>
- ❑ <https://github.com/iic-jku/osic-multitool>
- ❑ <https://link.springer.com/article/10.1007/s00502-023-01195-5>
- ❑ <http://www.infineon.com/schools>

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