Value and Opportunities in Open-Source for Circuit Design

Christoph Sandner, Senior Principal
Infineon Technologies Austria AG
Christoph.sandner@Infineon.com

Outline

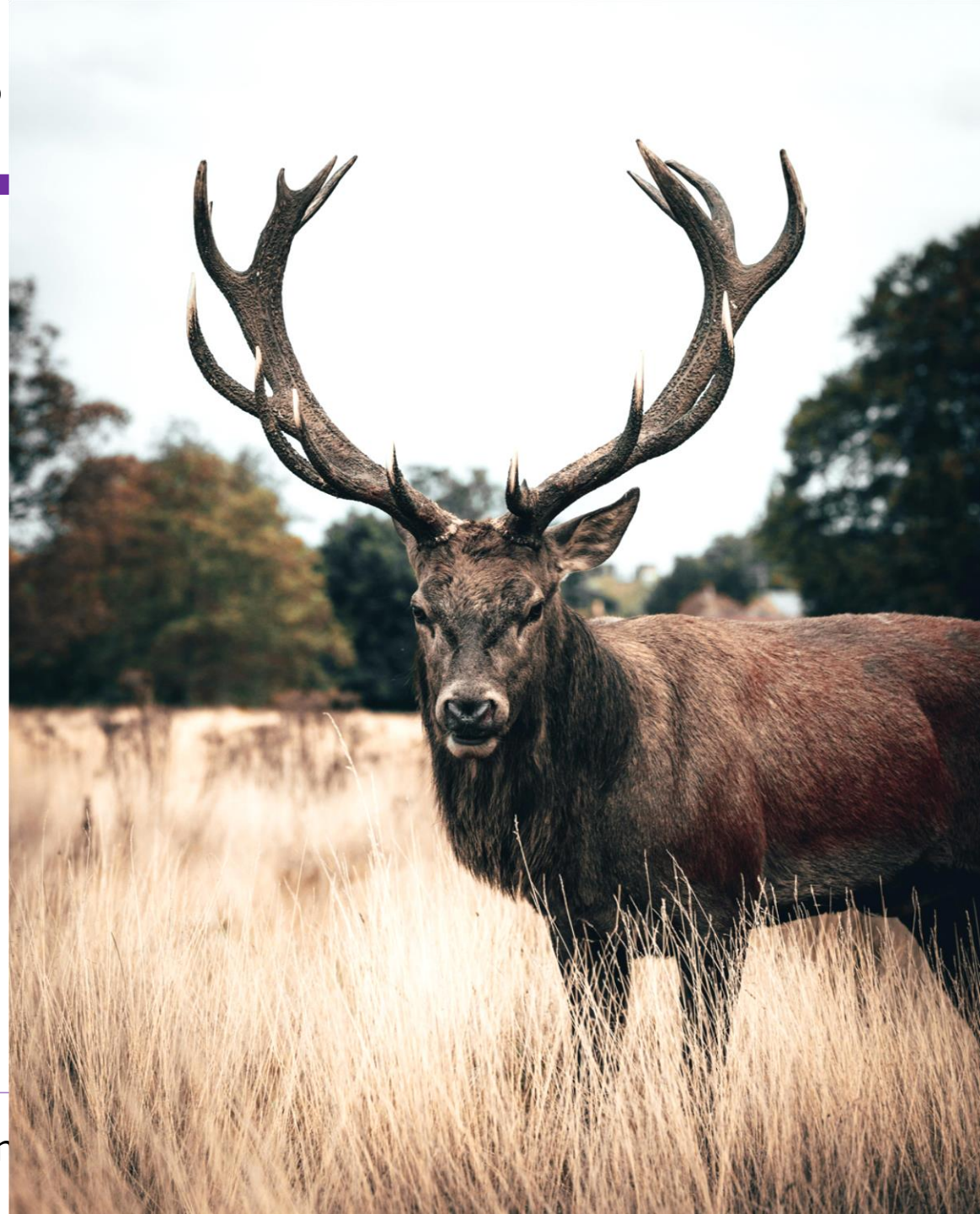
- Motivation for OS Hardware
- Relevant pillars:
  1. Education
  2. OS PDKs
  3. OS IP
  4. Disruptive Methods: (Analog Design) Automation

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

Why Hardware Collaboration?

- **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


DESIGNLINES | SOC DESIGNLINE

Chip Experts See Talent Shortage as Main Growth Hurdle

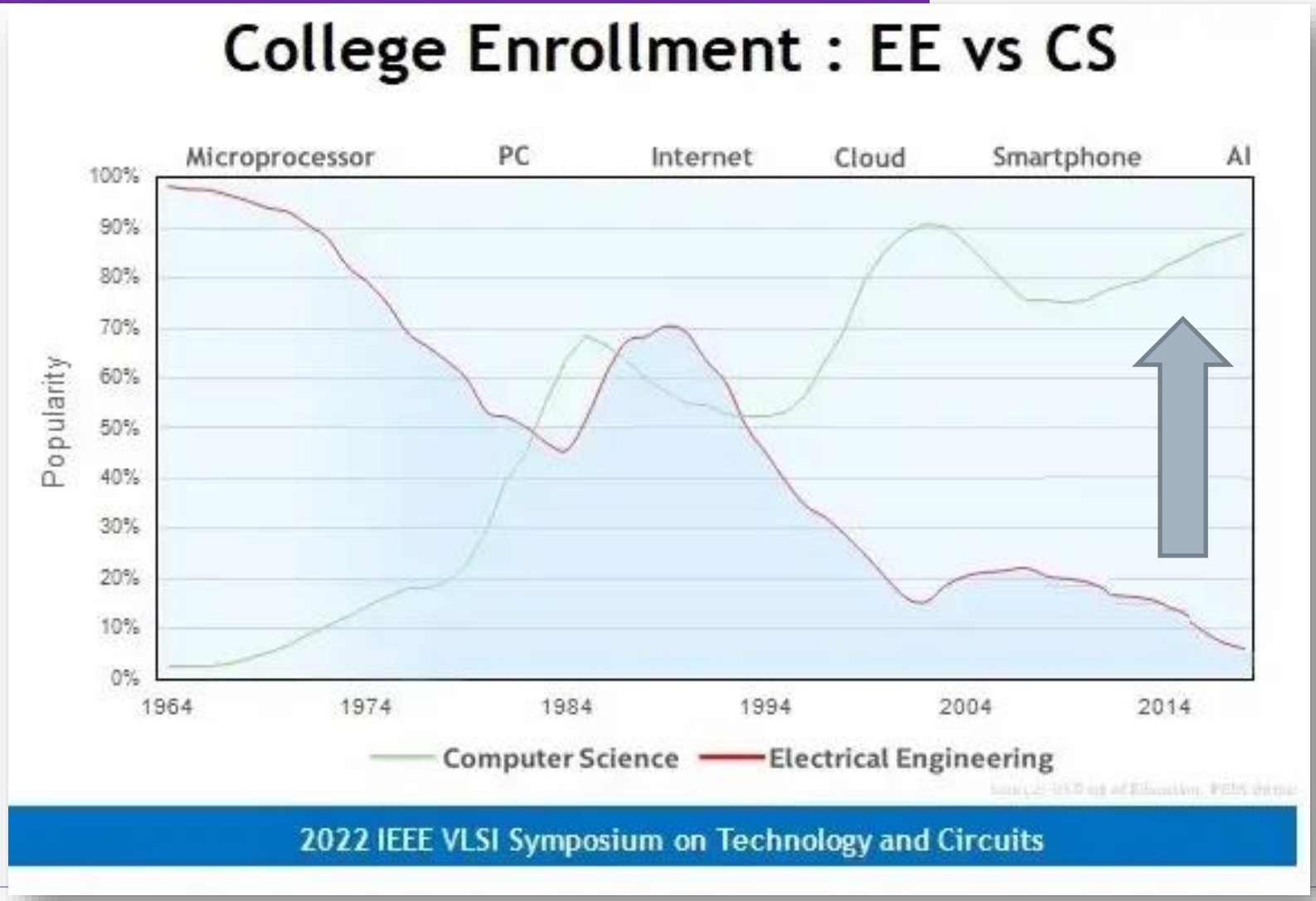
By Alan Patterson 07.21.2023 3

Share Post Share on Facebook Share on Twitter in

https://www.eetimes.com/chip-experts-see-talent-shortage-as-main-growth-hurdle/

- 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

Academia and Industry need to join forces!

Open-Source to the rescue?

OS Success Story:

https://riscv.org/

- 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

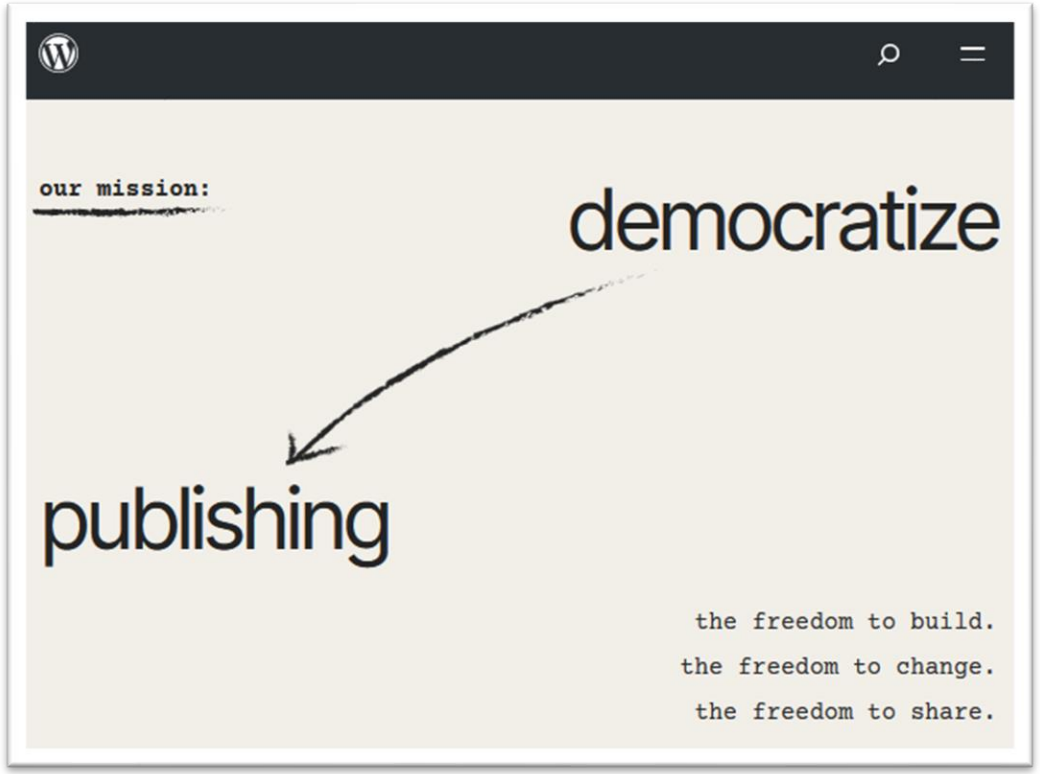
Market 2021: $445 million
CAGR >30% until 2027
Growing design ecosystem
both open and proprietary

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

OS Success Story: Wordpress

https://wordpress.org/about/

- 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

https://sscs.ieee.org/about/solid-state-circuits-directions/sscs-pico-program

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 [illegible] integrated circuit (IC) design. We envision a future [illegible] through a web browser, by anyone, anywhere and through open [illegible]

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.

…chips can be designed through a web browser, by anyone…

…help to accelerate the construction of the required ecosystem

OS to the Rescue? - Education

https://bit.ly/esscxxrc22-goog

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

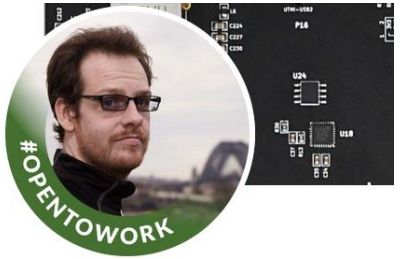
Future pathway for ASIC designer

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



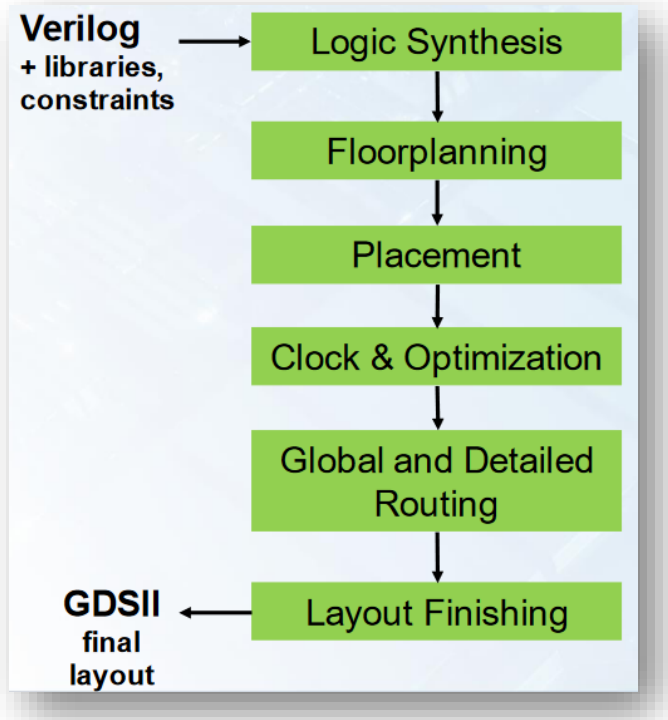
Tim (mithro) Ansell

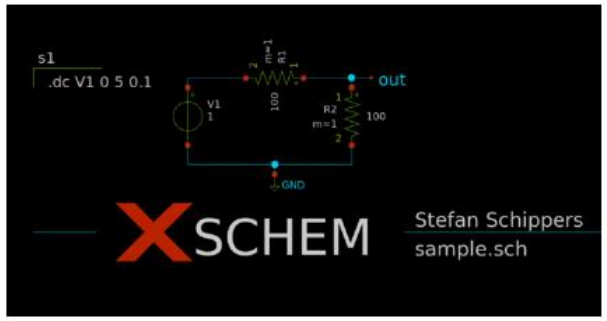
Google + skywater + GLOBAL FOUNDRIES

ihp

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, …





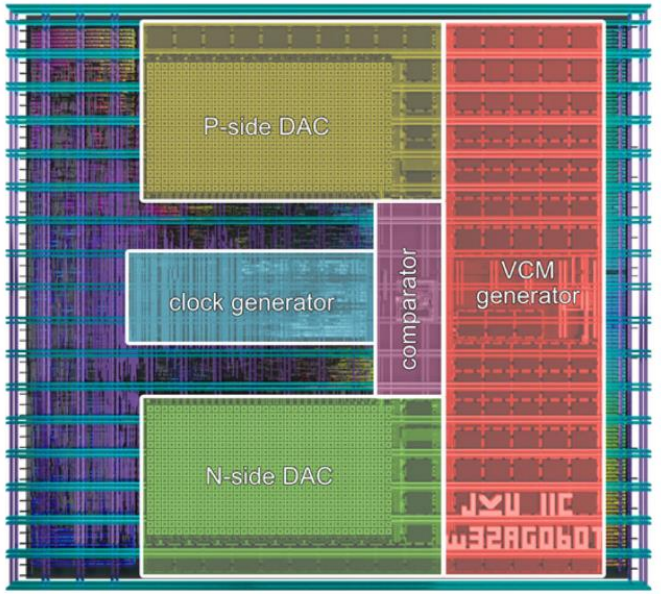
efabless.com

zero

Sandia National Laboratories Xyce

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

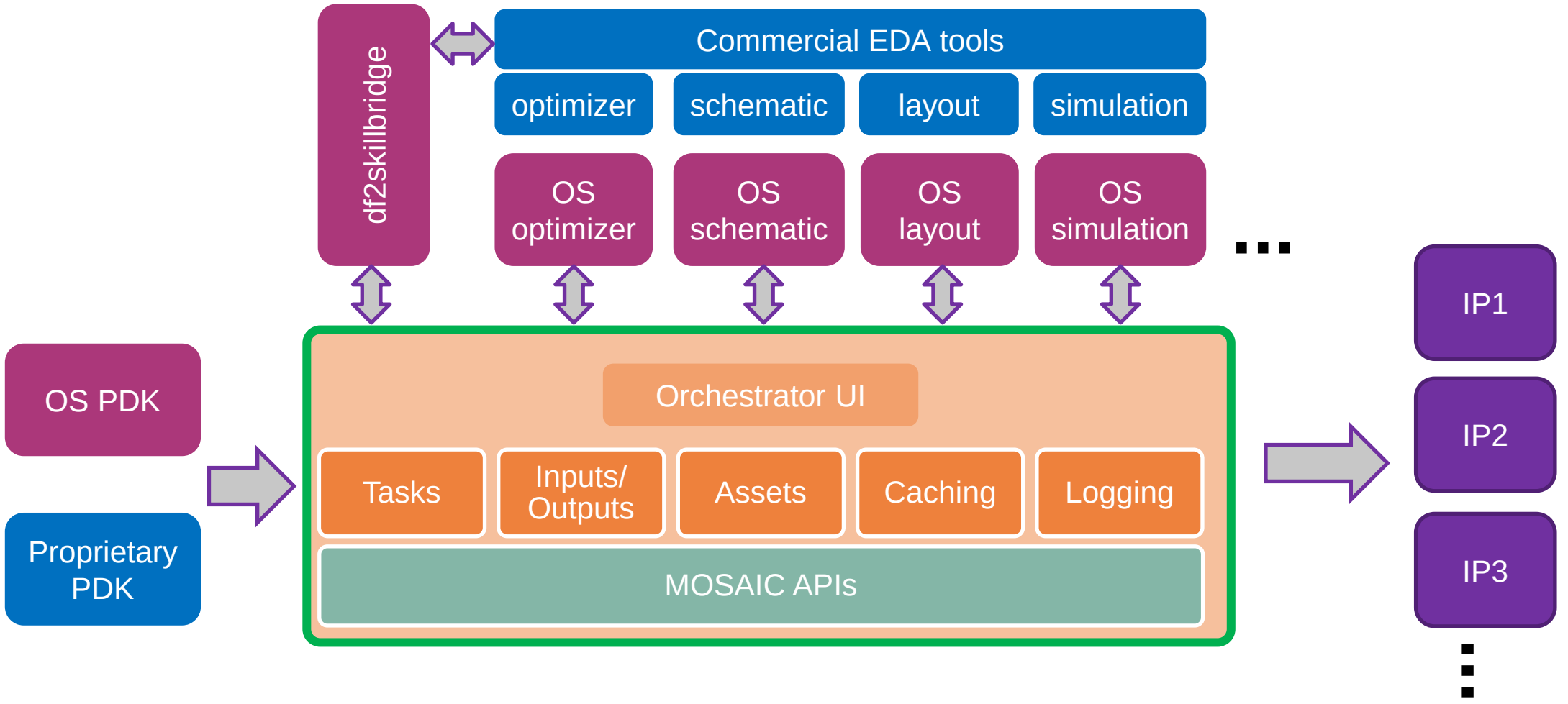
- **People!**
  - OS community often fueled by individuals
  - Companies step in if they see value
  - Mindset change in Hardware Industry needed:
    See OS as opportunity, not as a threat!
- **Money!**
  - New Government funding requires OS: Darpa, Chips Act, Germany, …
  - Seed funding, eg. shuttle 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 (https://www.mosaic-ic.org/)
- 2023 – Infineon Summer school
  - 50+ students invited on-site to learn about analog generators

http://www.infineon.com/schools

MOSAIC Analog Design Framework



Why OS - Opportunities

- 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

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

How to get Industry into OS? Benefits

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.

[GPT4.0]

2024: We continue, step by step…

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://www.mosaic-ic.org
- https://www.chipsalliance.org/
- https://www.openhwgroup.org/
- https://chipyard.readthedocs.io/en/stable/index.html
- https://developers.google.com/silicon
- https://bit.ly/esscxxrc22-goog
- https://www.klayout.de/
- https://laygo2.github.io/
- https://github.com/idea-fasoc/OpenFASOC
- http://opencircuitdesign.com/magic/
- 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

Acknowledgement

This work is funded by the Austrian Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology, the Austrian Federal Ministry of Digital and Economic Affairs, and implemented by austria wirtschaftsservice (aws) and the Austrian Research Promotion Agency (FFG)

in the frame of the

Important Project of Common European Interest (IPCEI)

on Microelectronics and Communication Technologies (ME/CT).