Google/SkyWater and the Promise of the Open PDK

The New Ecosystem of Open Source Silicon

Tim Edwards

SVP Analog & Platform

efabless

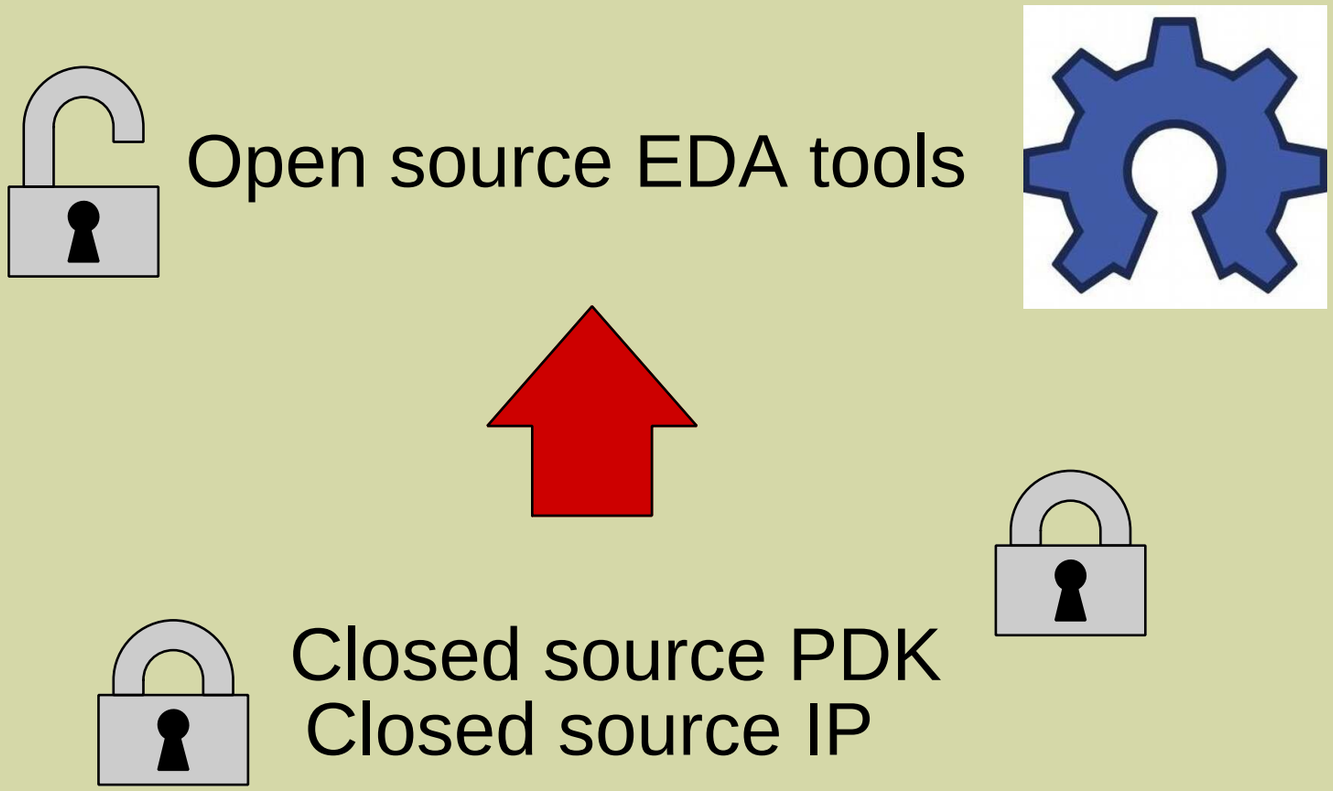
efabless.com

Open Circuit Design

opencircuitdesign.com

Google/SkyWater and the Promise of the Open PDK

Every EDA tool must have access to potentially proprietary information in a Process Design Kit (PDK)



Google/SkyWater and the Promise of the Open PDK

Every EDA tool must have access to potentially proprietary information in a Process Design Kit (PDK)

Device characteristics

- SPICE models
- Verilog models

Design rules

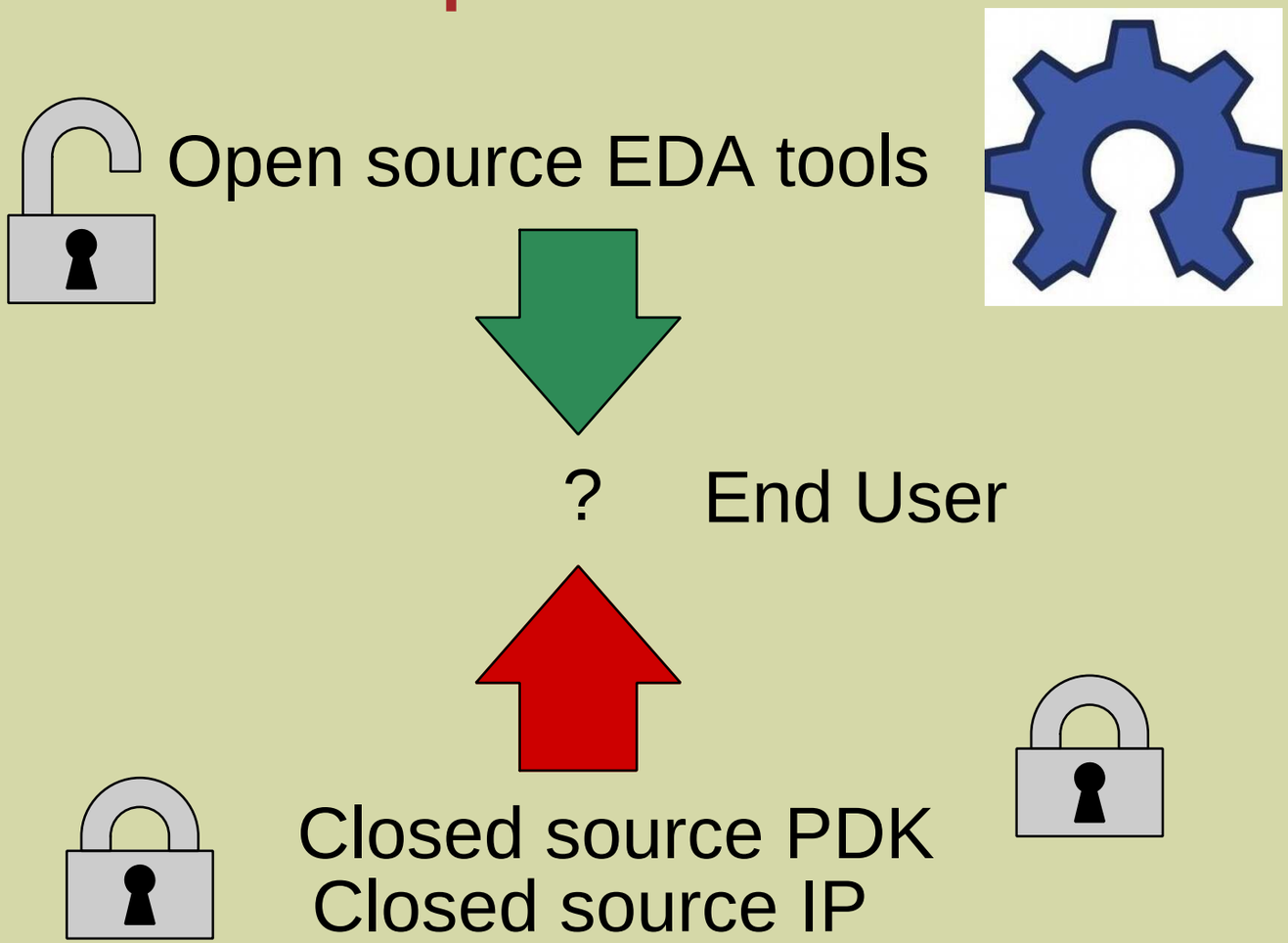
- DRC/ERC
- Extraction

IP Libraries

- GDS data
- Timing characteristics

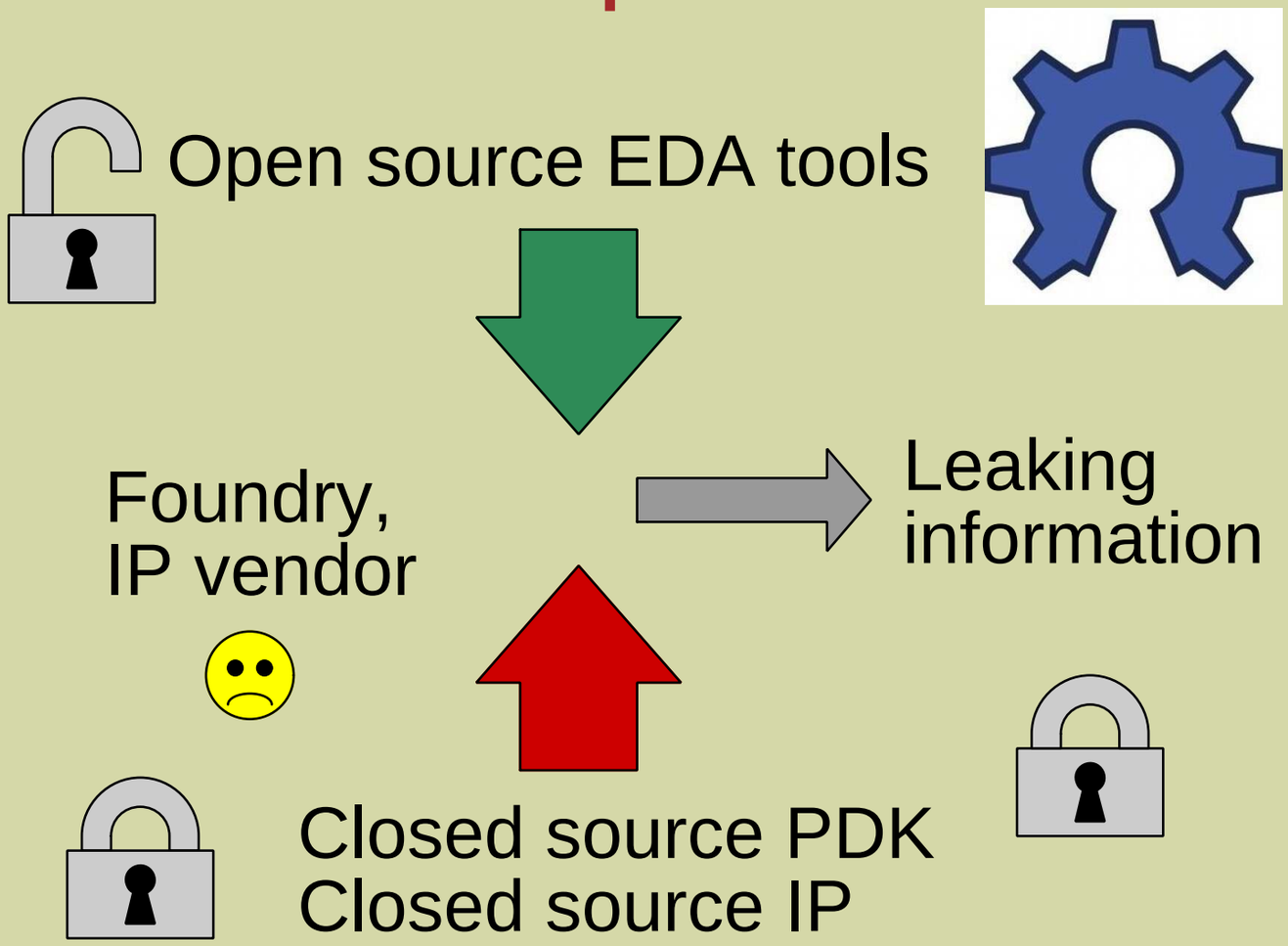
Google/SkyWater and the Promise of the Open PDK

Here is the problem:



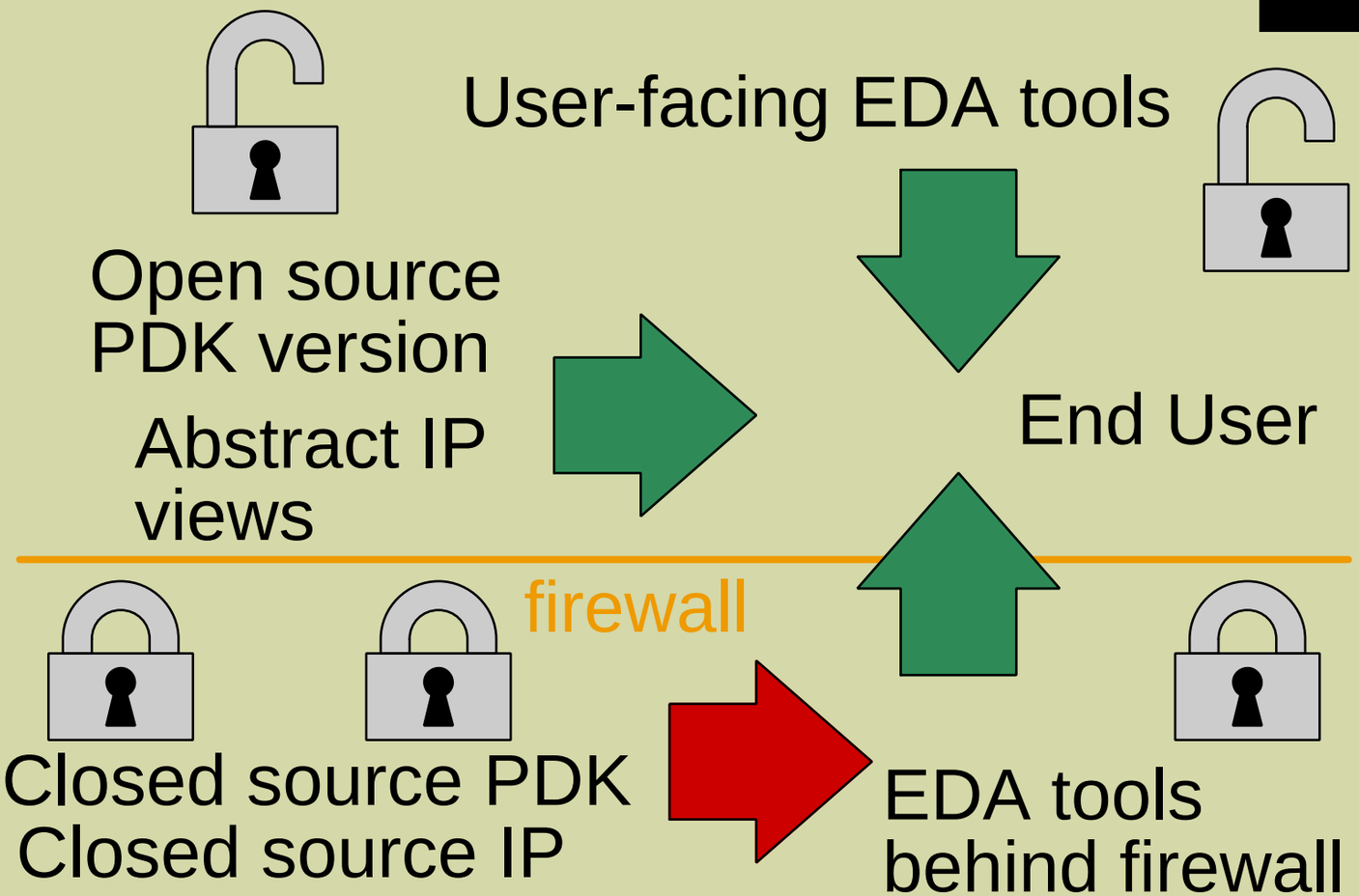
Google/SkyWater and the Promise of the Open PDK

Here is another problem:



Google/SkyWater and the Promise of the Open PDK

Here is one solution (used at efabless):



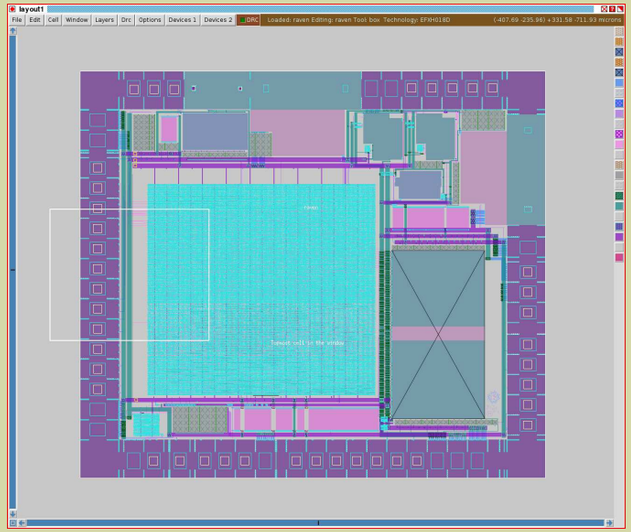
Google/SkyWater and the Promise of the Open PDK

Commercial EDA Tool Vendors

Silicon Foundries

Google/SkyWater and the Promise of the Open PDK

Early open-source EDA tools



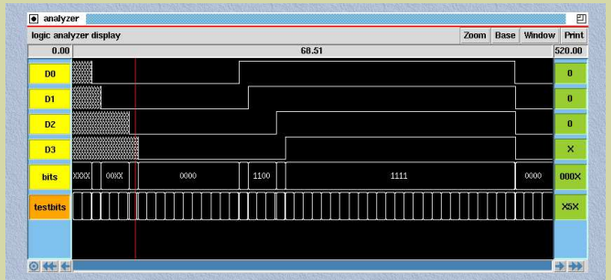
SPICE

Magic

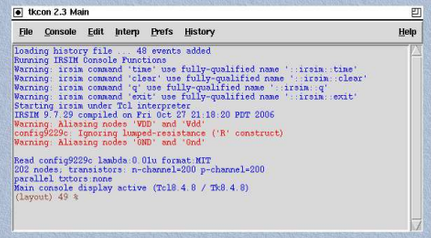
VIS/SIS

IRSIM

.
.
.



The "analyzer" graphic display in IRSIM 9.7



The IRSIM command console in the Tcl/Tk based version 9.7

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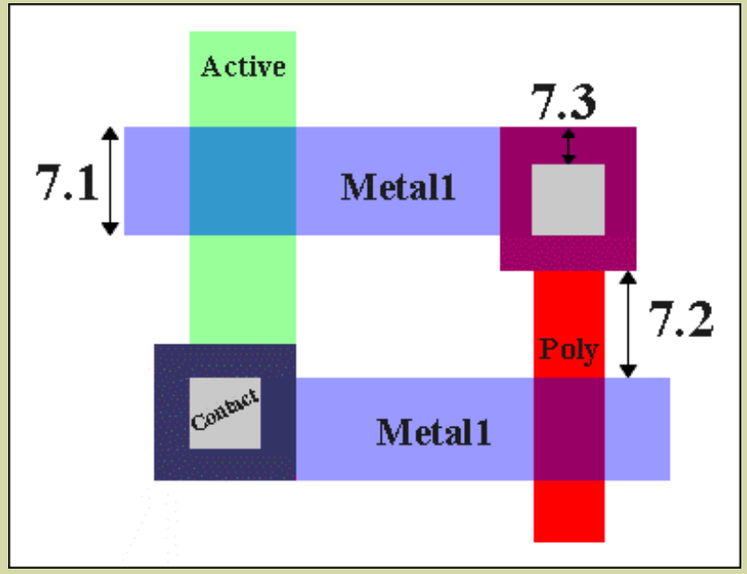
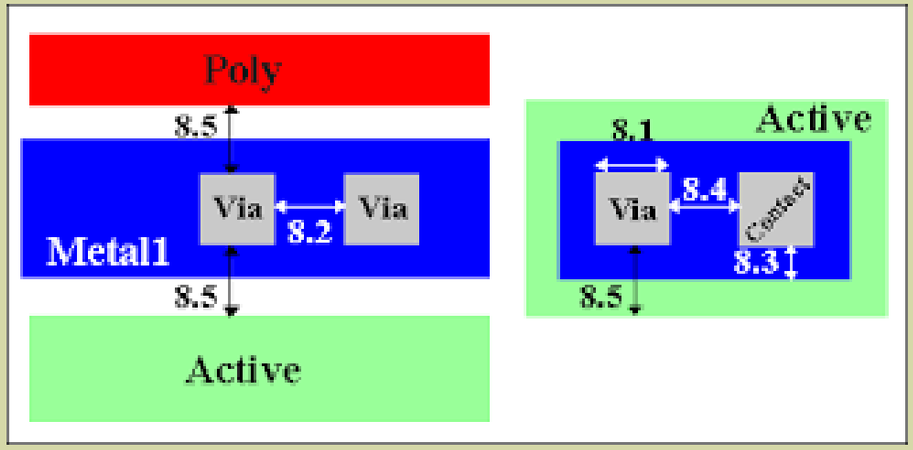


SCMOS

Scalable CMOS



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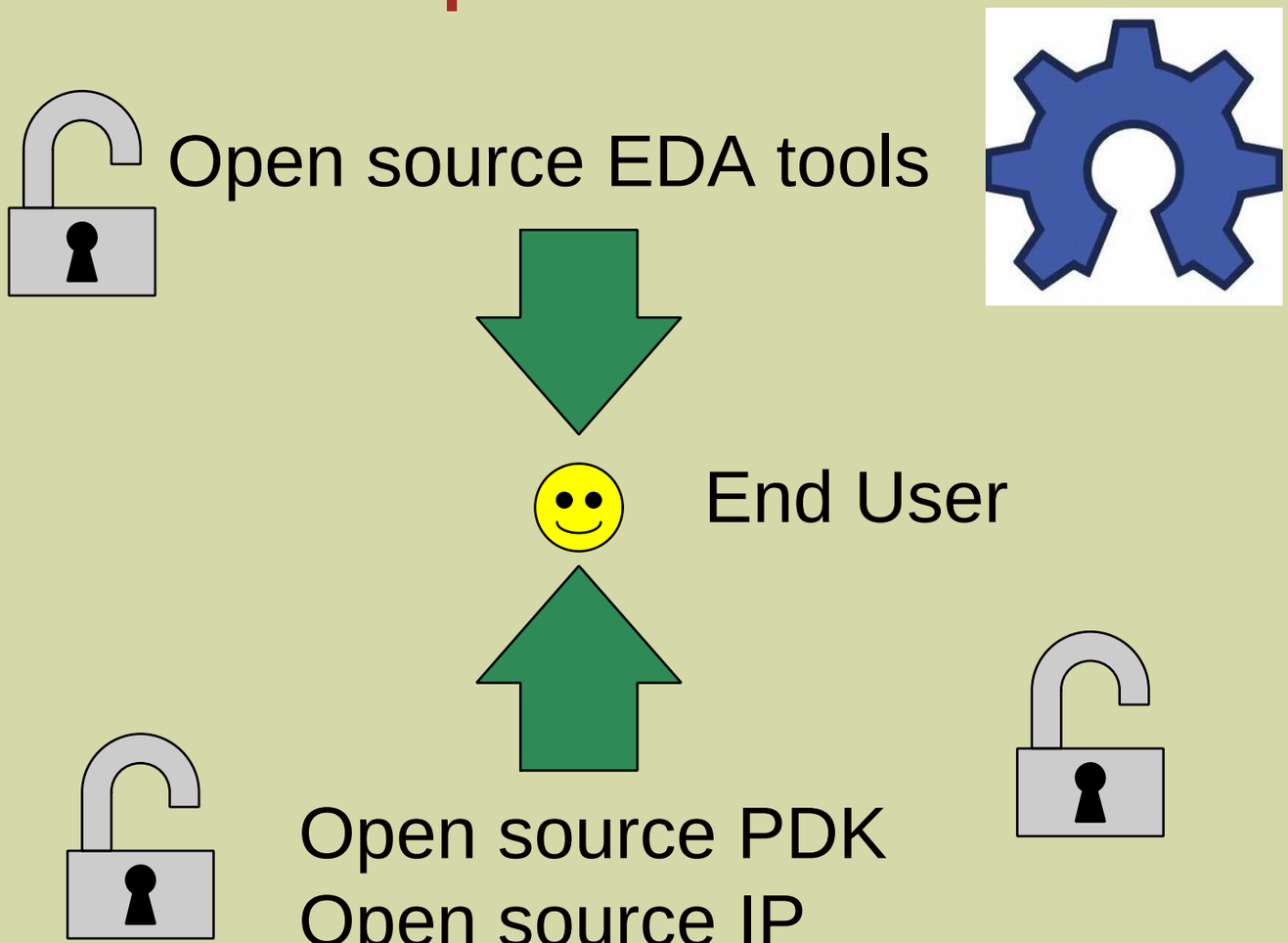
Here is the preferred solution:



Google/SkyWater and the Promise of the Open PDK

https://github.com/google/skywater-pdk

https://fossi-foundation.org/dial-up

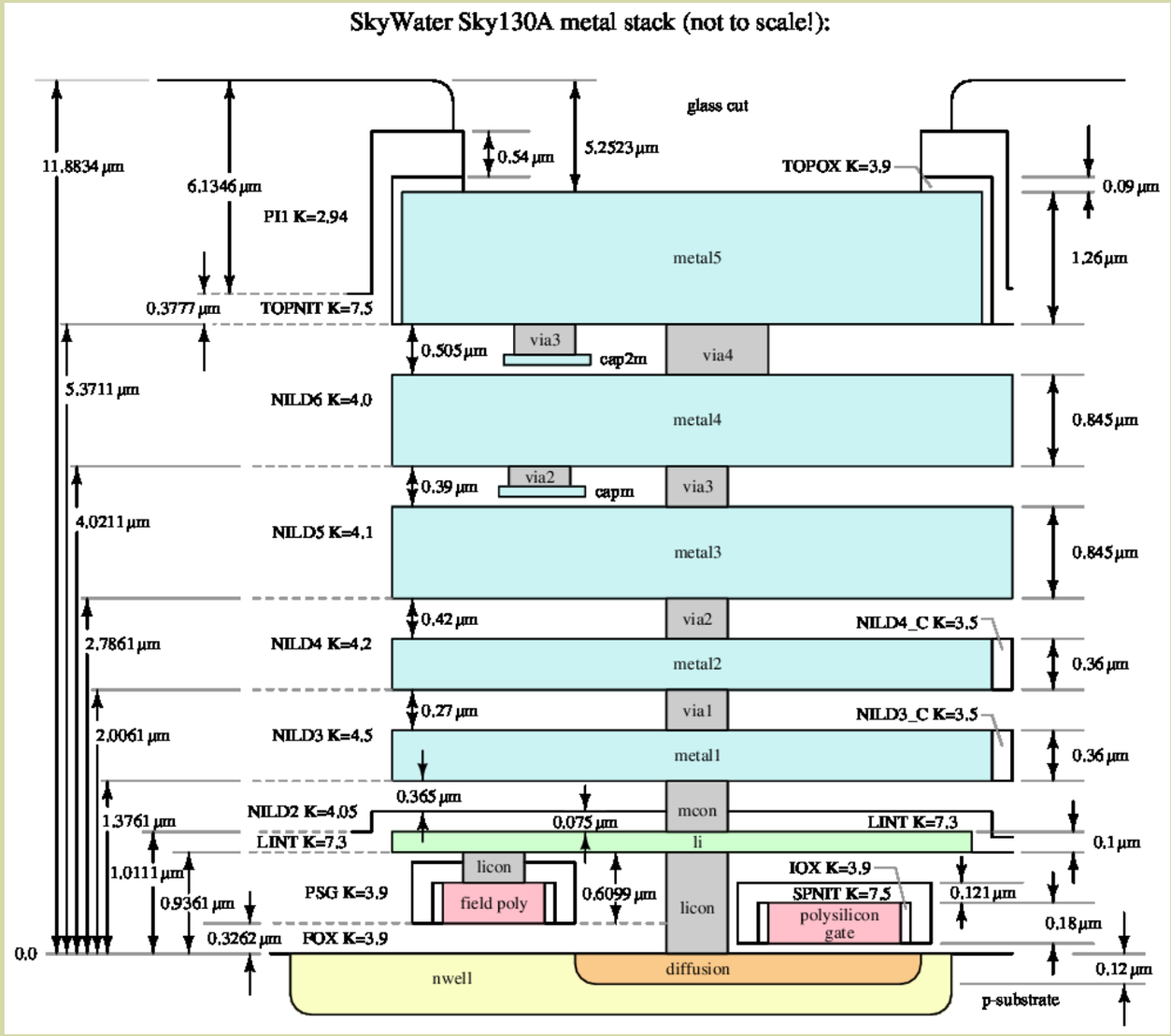
Slack channel:

skywater-pdk.slack.com

Join here:

https://join.skywater.tools

Google/SkyWater and the Promise of the Open PDK



130 nm, 6 metal stack process

Google/SkyWater and the Promise of the Open PDK

The Business Case for an Open Source PDK

Non-Manufacturing Costs to Foundries

Maintaining NDAs

Customer Tracking

Customer Support

PDK Development

Customer Support

Download Sites

Issue Tracking

Documentation

IP Library Development

Google/SkyWater and the Promise of the Open PDK

The Business Case for an Open Source PDK

IP Library Development—Typical needs

Digital Standard Cell Libraries

Padframe I/O, ESD

RAM, ROM Compilers

Crystal Oscillator

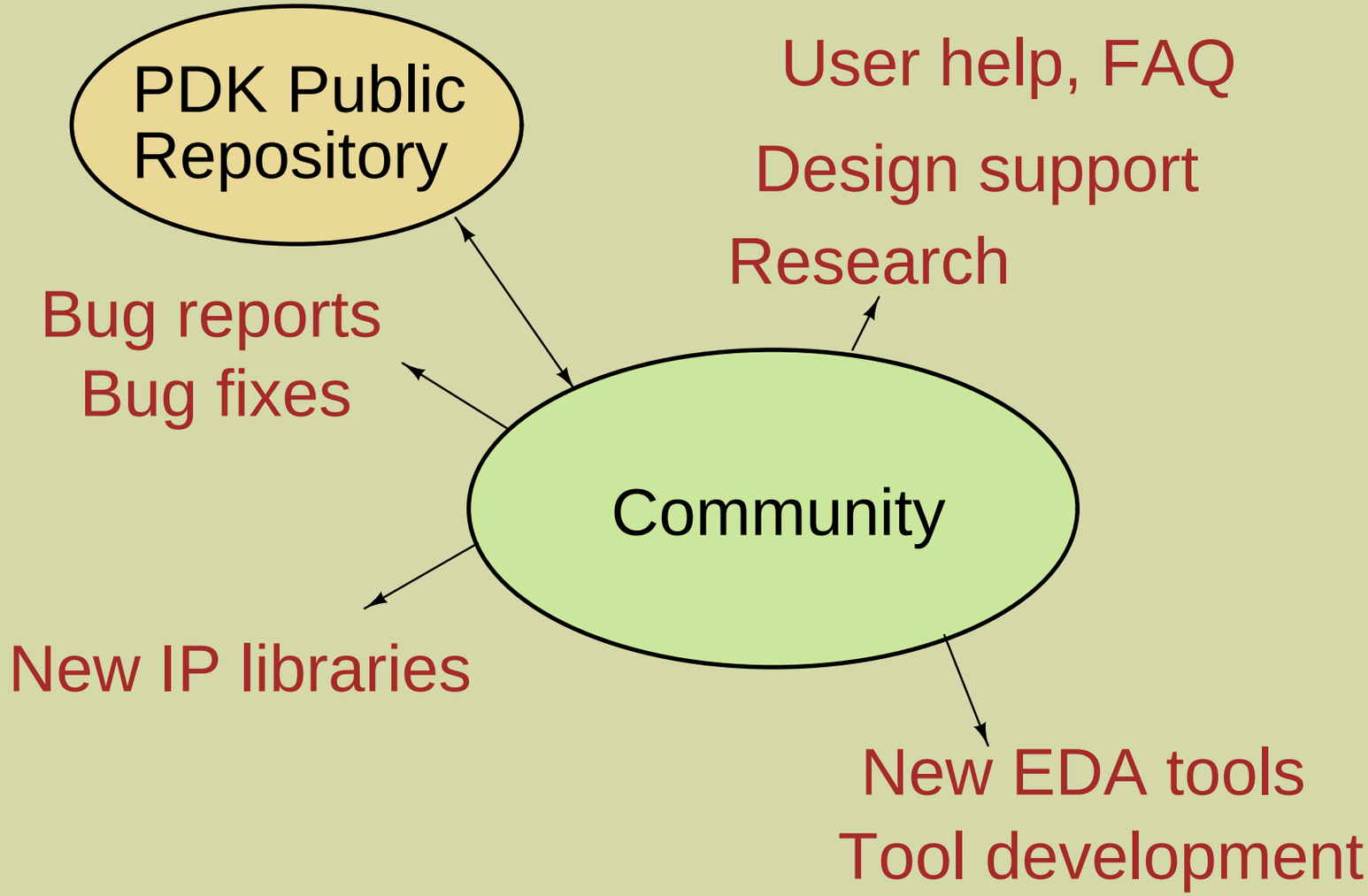
Voltage Regulator

Bandgap Reference

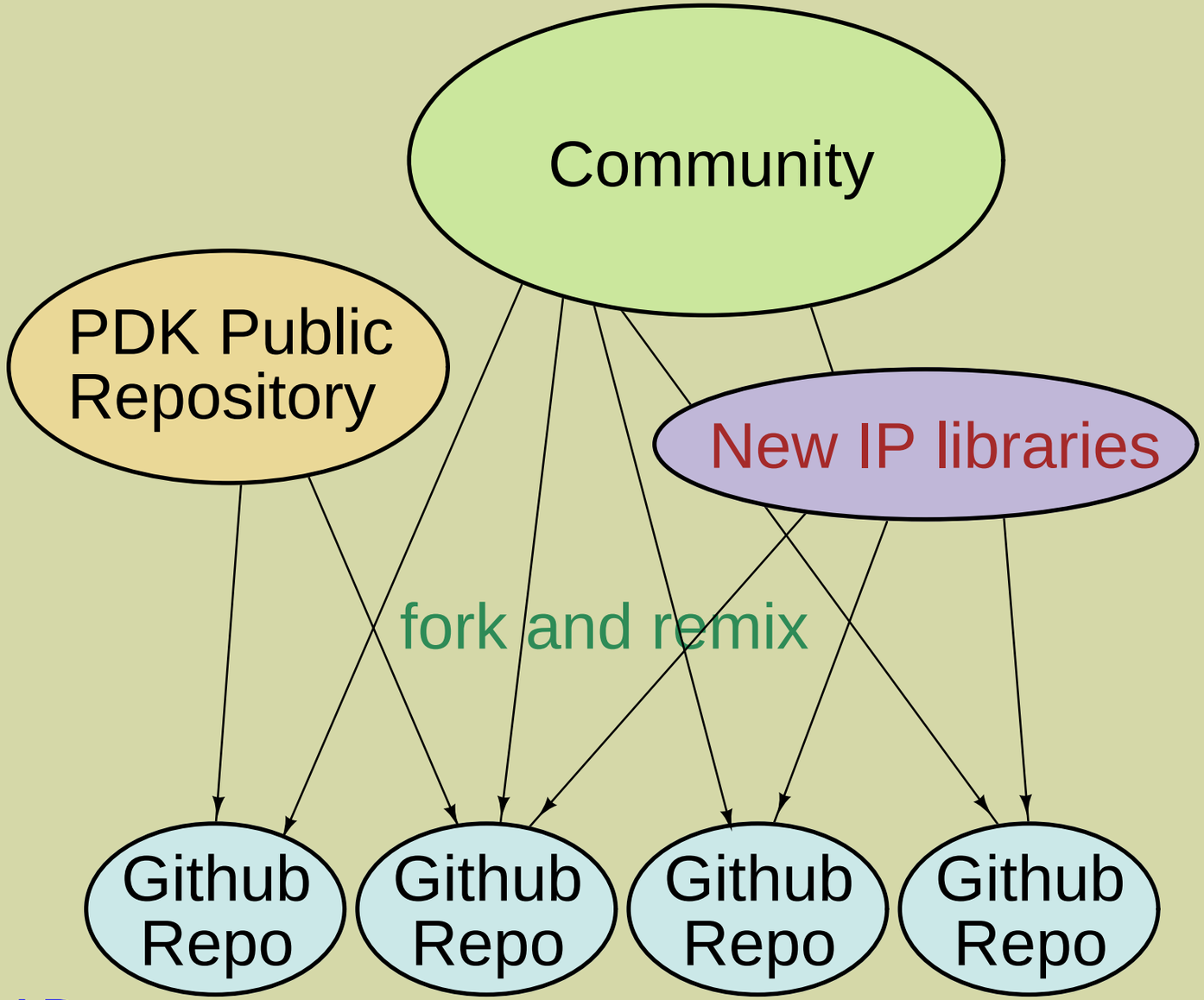
Power-on-Reset

Google/SkyWater and the Promise of the Open PDK

The Business Case for an Open Source PDK



Google/SkyWater and the Promise of the Open PDK



Google/SkyWater and the Promise of the Open PDK

Google/SkyWater Open PDK:

Emphasis on Open Source Tools

Use of Common File Formats

On-line Documentation

SkyWater PDK Components:

SPICE models (at all corners)

DRC / ERC rules

Standard cell libraries

Primitive device libraries

I/O Pad libraries

SRAM cell layout

Google/SkyWater and the Promise of the Open PDK

The Downside is the Challenge:

Need new Open Source Tools

Need full integrated flows

Digital

Mixed-Signal

Analog

Google/SkyWater and the Promise of the Open PDK

Bug Reporting and Fixing:

Go to Issue Tracker

Post reproducible example

Patch gets pushed to repo

Pull patched repo

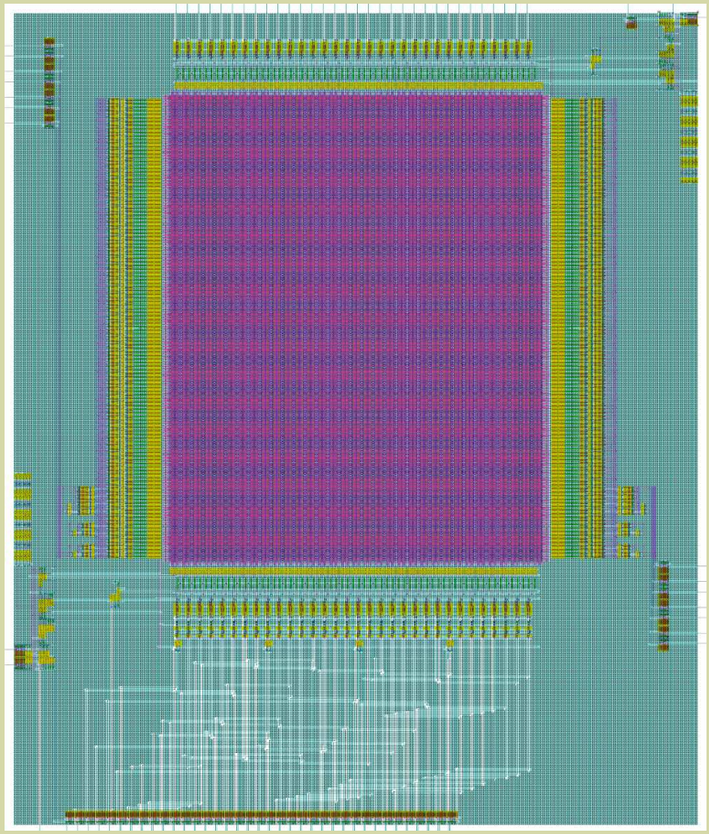
Google/SkyWater and the Promise of the Open PDK

Project Partners: UCSC

https://github.com/VLSIDA/OpenRAM

OpenRAM

(Also see: fossi-foundation.org/dial-up/)



2k×32 SRAM

in SkyWater 130nm

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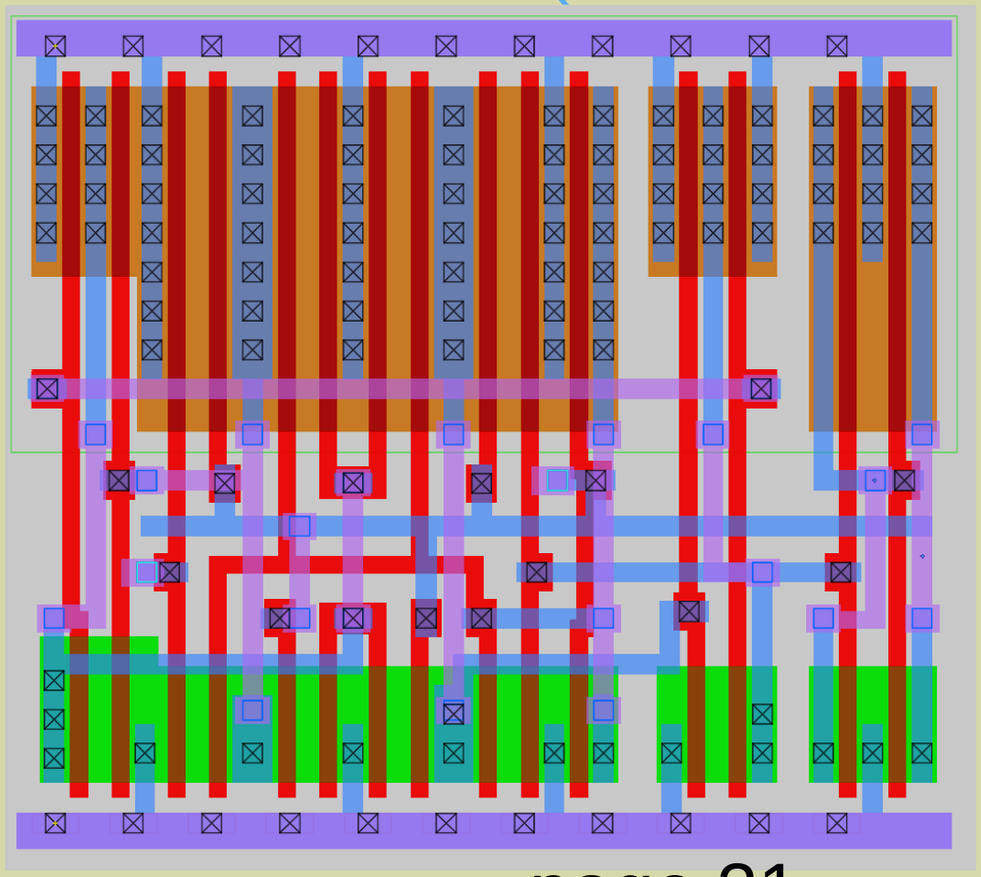
Project Partners: OSU

OSU Standard Cell Library https://github.com/stineje/OSU_130_PDK

(Also see: fossi-foundation.org/dial-up/)



dffsx1

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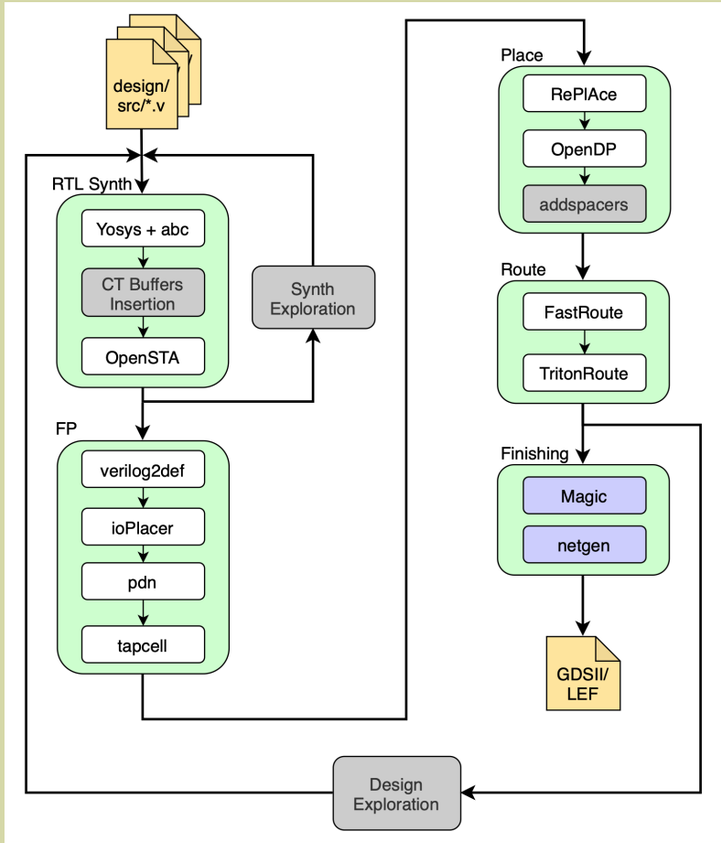
Project Partners: AUC https://github.com/efabless/openlane

OpenLane (Also see: fossi-foundation.org/dial-up/)



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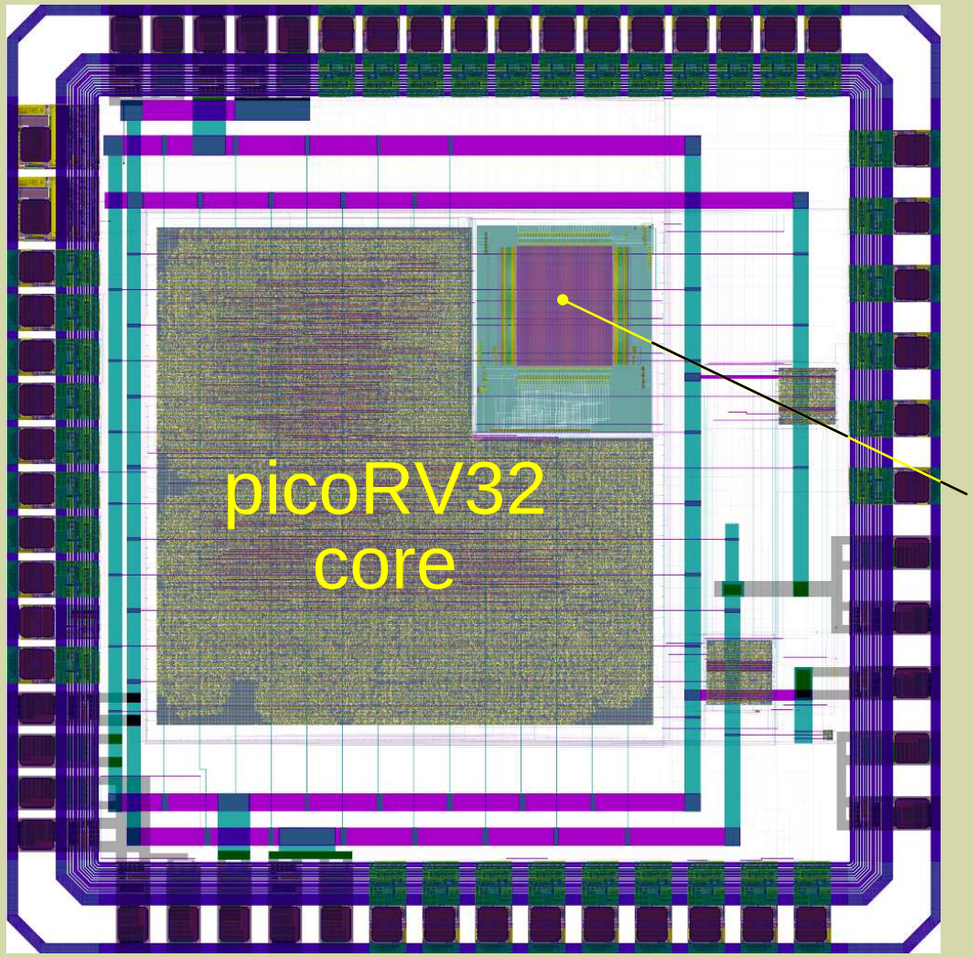
Project Partners:



efabless

striVe processor

RISC-V (picoRV32) microcontroller

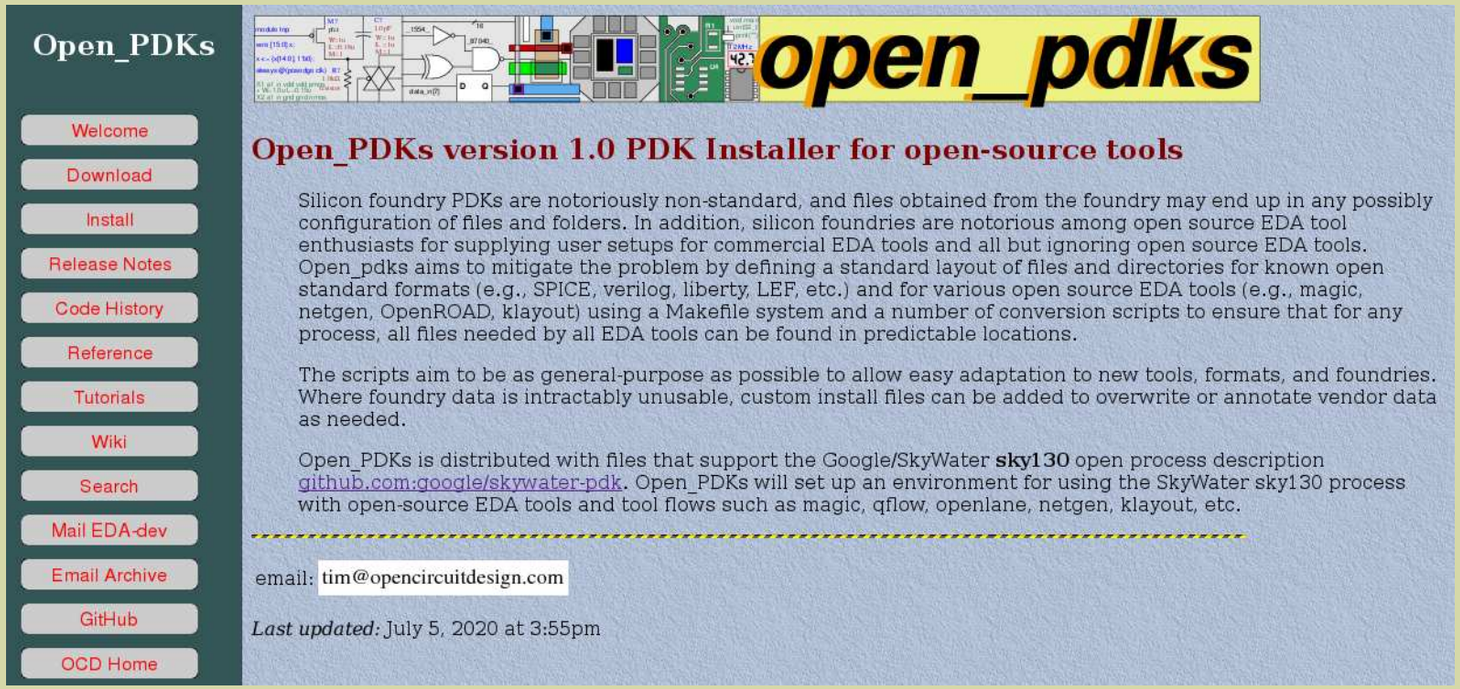
(Also see: fossi-foundation.org/dial-up/)

synthesized, placed, and routed with OpenLane

Google/SkyWater and the Promise of the Open PDK

Project Partners: Open Circuit Design

open_pdks http://opencircuitdesign.com/open_pdks



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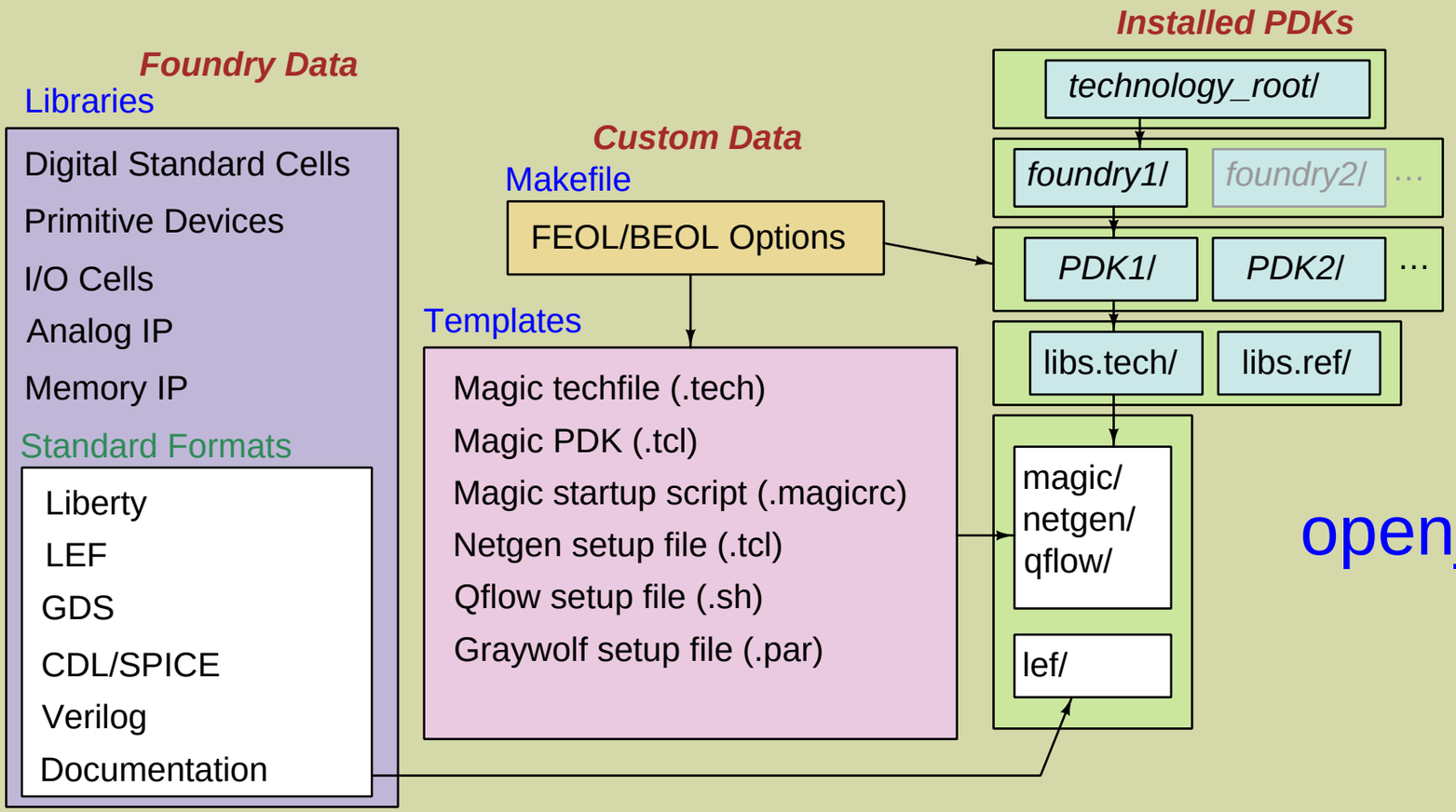


open_pdks PDK installation

```
configure
make
make install
```

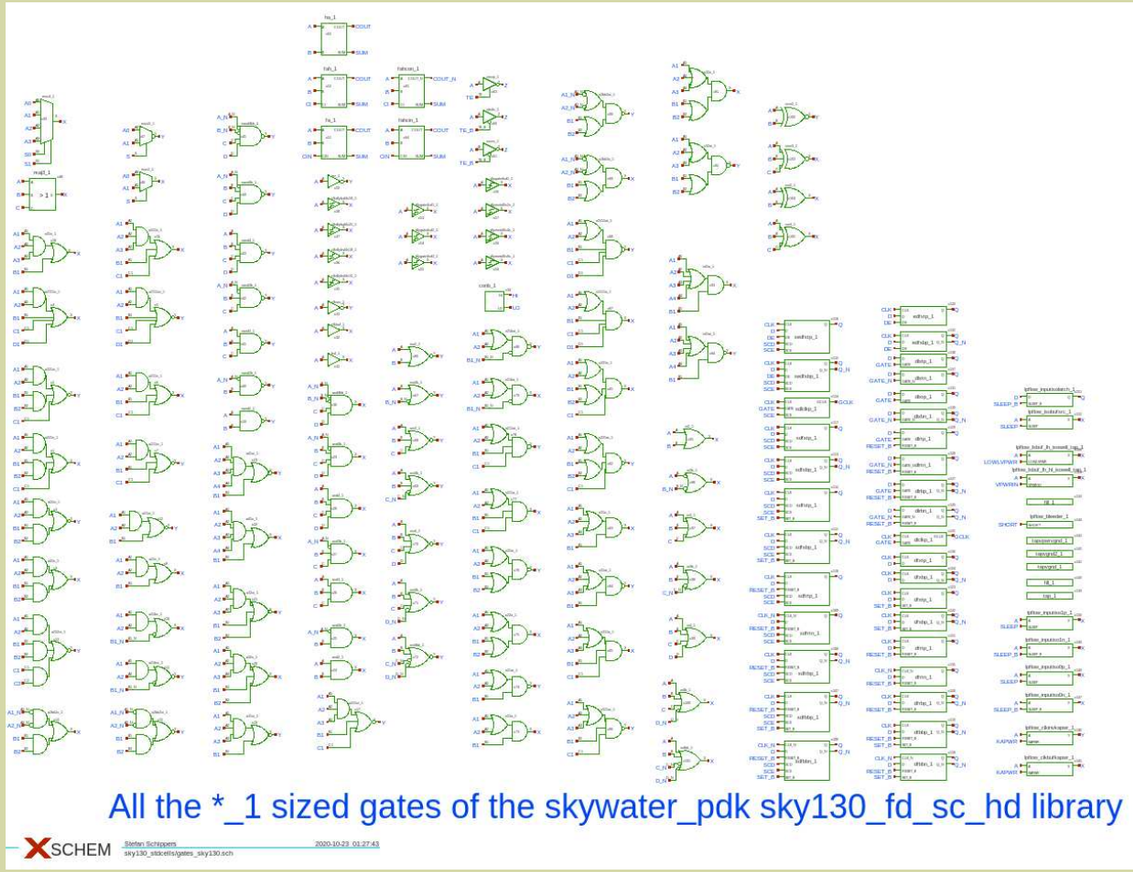
Google/SkyWater and the Promise of the Open PDK

Project Partners:

xschem

Stefan Schippers

https://repo.hu/projects/xschem



Google/SkyWater and the Promise of the Open PDK

New software projects:

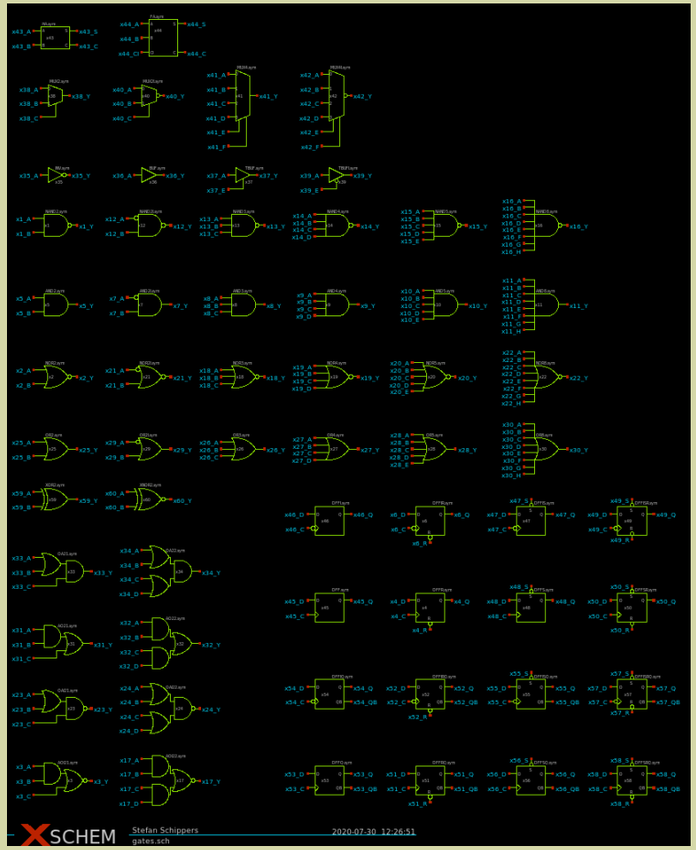
2020 summer internships at efabless / Open Circuit Design

Arjun Rakheja

https://github.com/arjunr10/eda-symbol_libraries

Automatic Symbol Library Generation

```
liberty file
   cell ()
      function()
   cell ()
      function()
   ...
```



Google/SkyWater and the Promise of the Open PDK

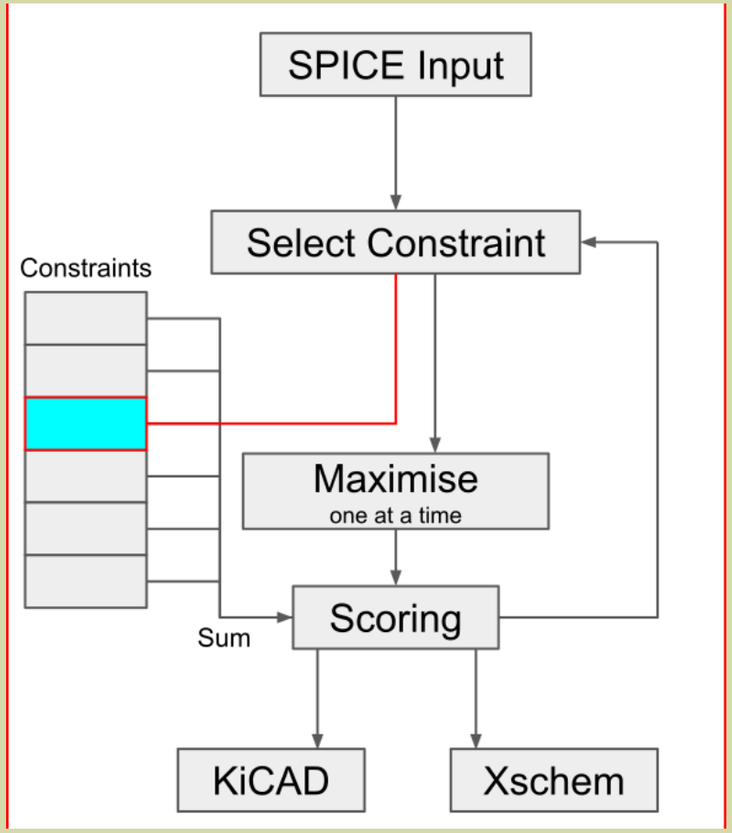
New software projects:

2020 summer internships at efabless / Open Circuit Design

Aidan Goettsch

https://github.com/aidangoettsch/asg.git

Automatic Schematic Generation



SPICE netlist
to
schematic

Google/SkyWater and the Promise of the Open PDK

The Google/SkyWater shuttle runs on efabless:

Free shuttle run sponsored by Google!

(“free” as in beer)

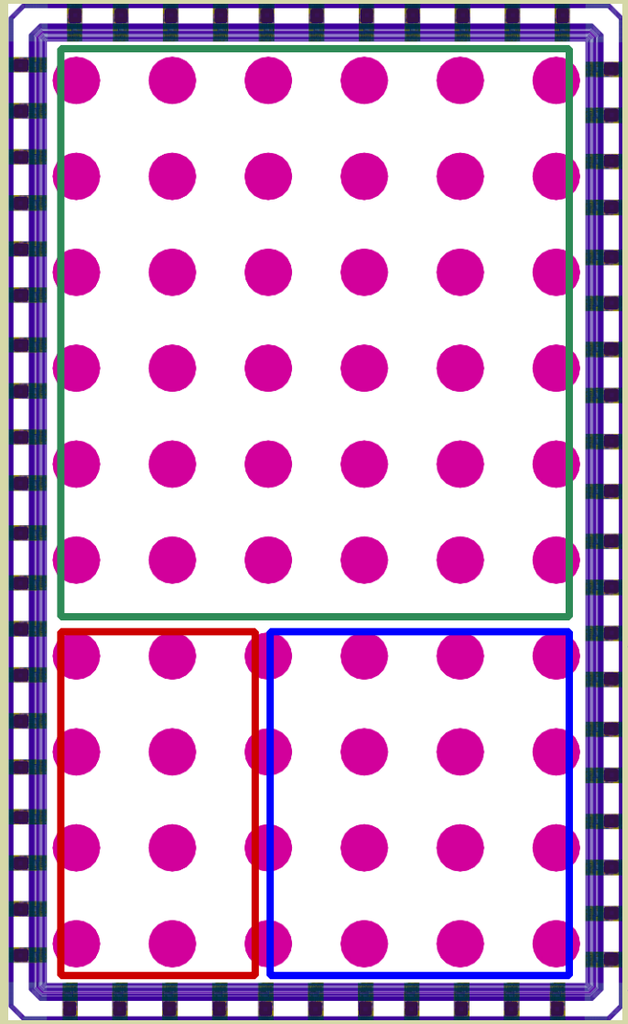
Coming end of November 2020

Experimentation Encouraged!

Submit designs to:

Google/SkyWater and the Promise of the Open PDK

The Google/SkyWater shuttle runs on efabless:



user project area

storage area (SRAM)

management area (picoRV32)

"Caravel" user project harness

60-pin WLCSP bump bond

3.2 × 5.3 µm

Google/SkyWater and the Promise of the Open PDK

The Google/SkyWater shuttle runs on efabless:

"Caravel" user project harness

The designer:

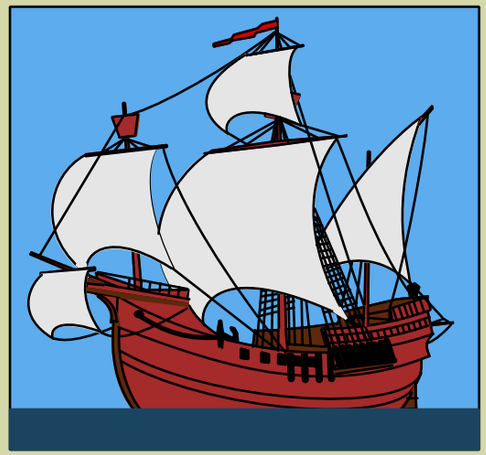
Creates open-source IP

Puts IP in the Caravel design

Posts project on github

Submits project to efabless

Gets back packaged parts and parts assembled on a development board

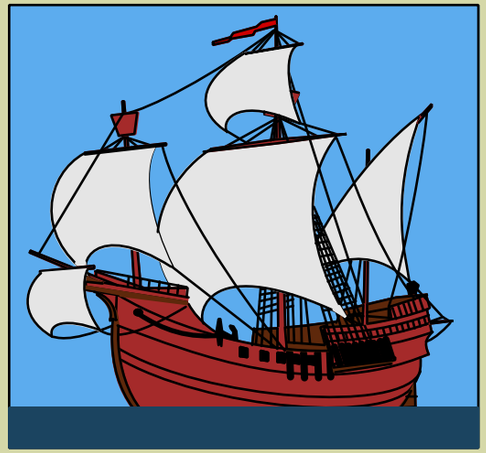


Google/SkyWater and the Promise of the Open PDK

The Google/SkyWater shuttle runs on efabless:

"Caravel" user project harness

Google/SkyWater/efabless:



Gets new open-source IP

Enhances offerings for the next shuttle run

Gets a community of designers

Google/SkyWater and the Promise of the Open PDK

In Conclusion

Google/SkyWater is publicly available on github

Fully open-source process foundry description

Fully open-source IP libraries

Emphasis on open source tools

Community of designers & developers

Keep it open source!