

Google/SkyWater and the Promise of the Open PDK

The New Ecosystem of Open Source Silicon



Tim Edwards
SVP Analog & Platform



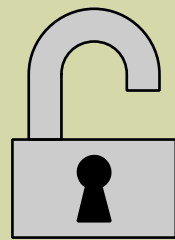
efabless
efabless.com



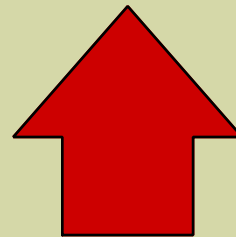
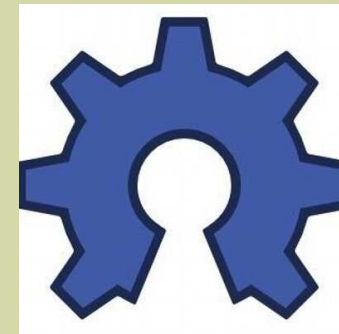
Open Circuit Design
opencircuitdesign.com

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)



Open source EDA tools



Closed source PDK
Closed source IP



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

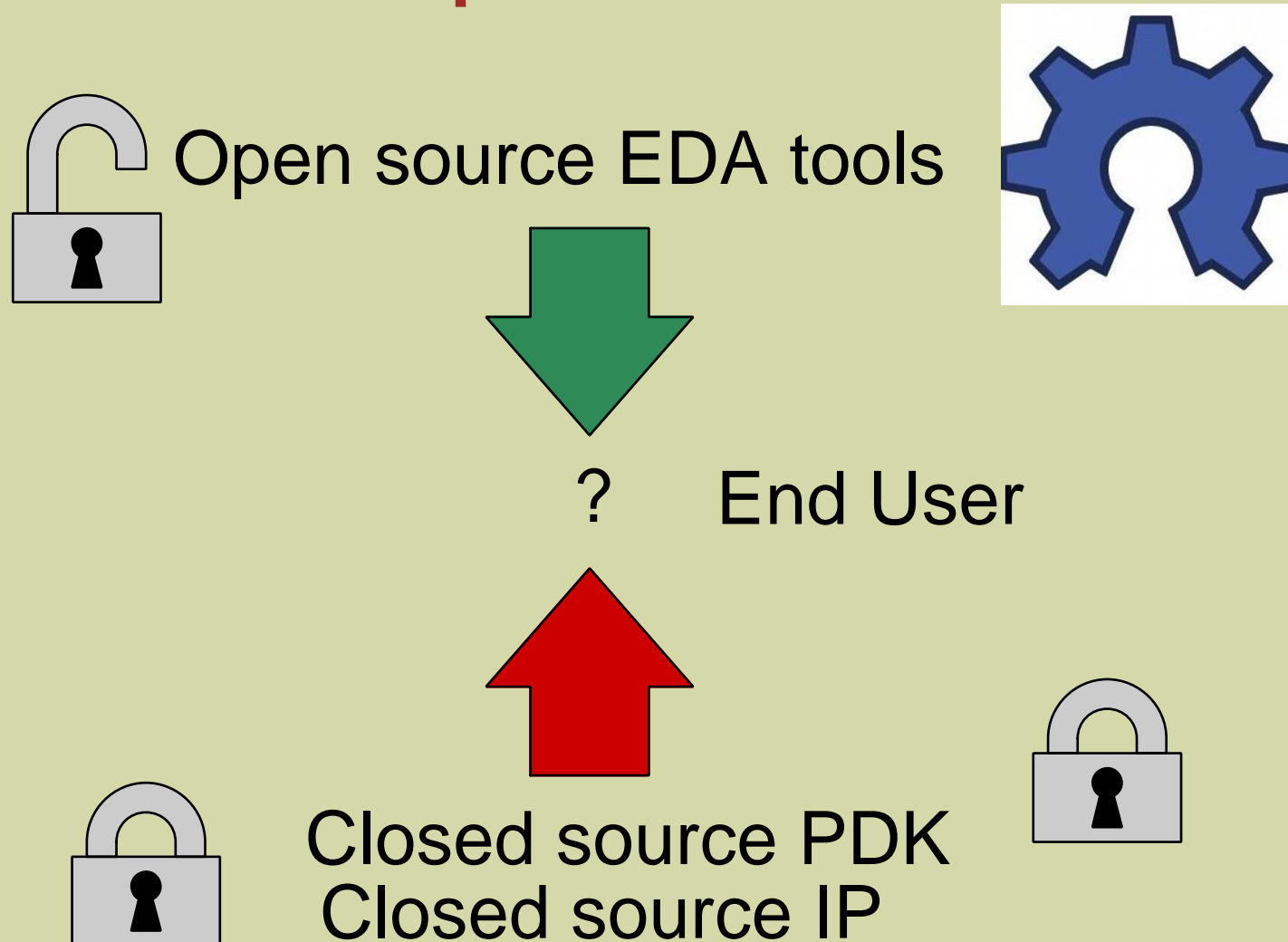
IP Libraries

- GDS data

- Timing characteristics

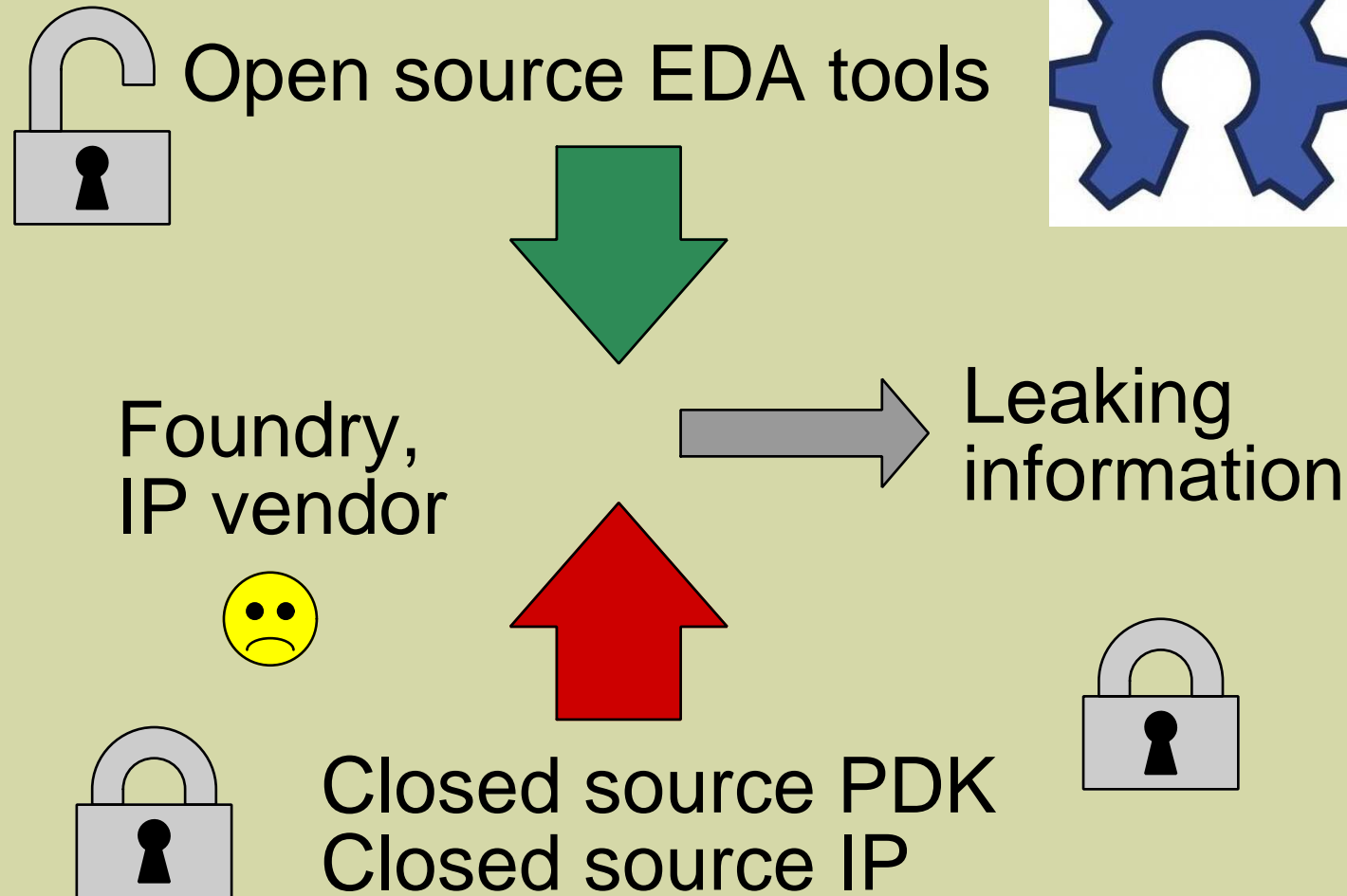
Google/SkyWater and the Promise of the Open PDK

Here is the problem:



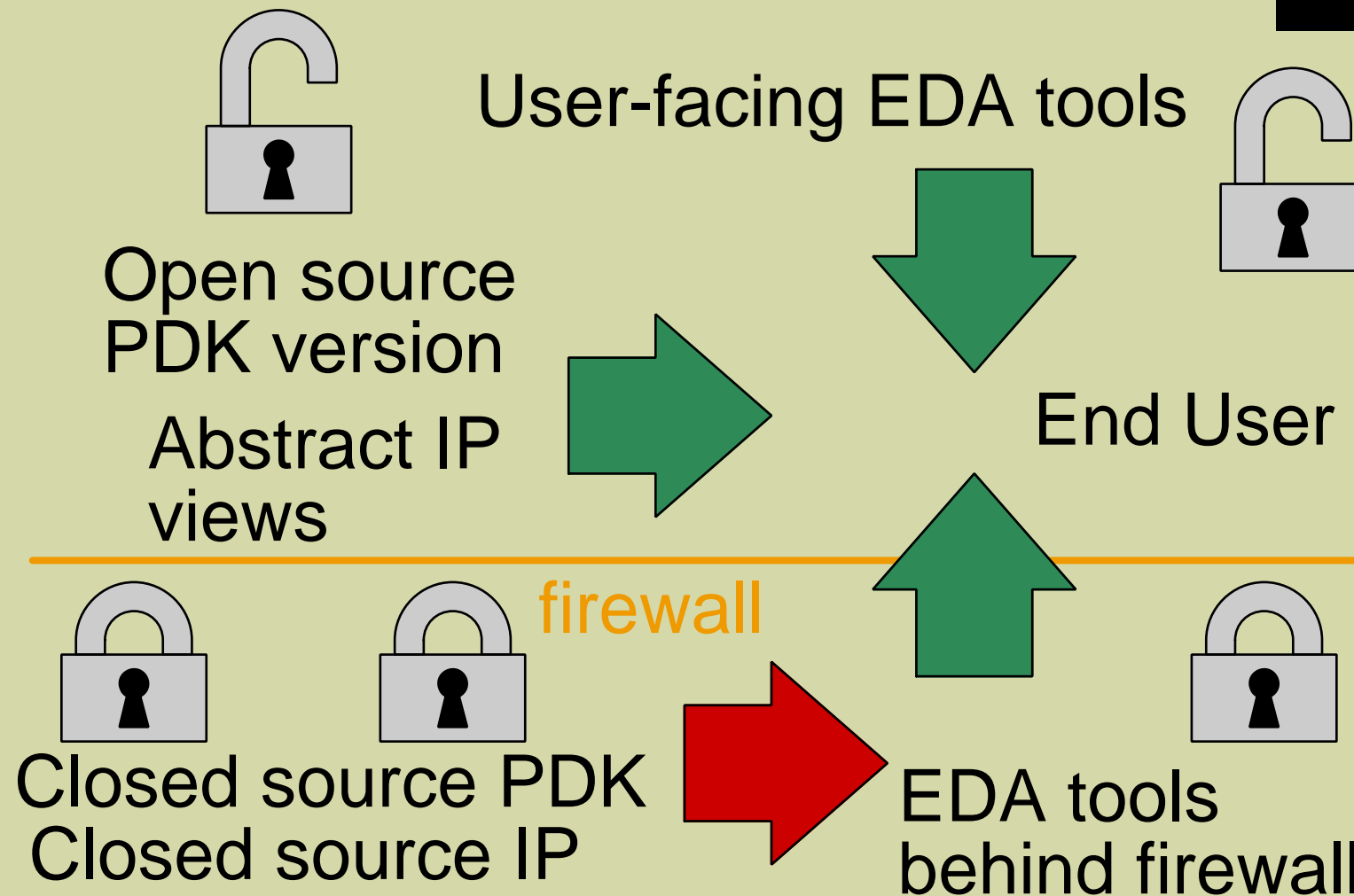
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Here is another problem:



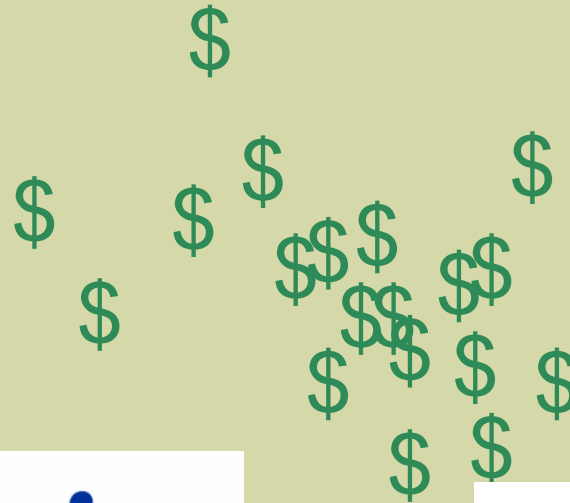
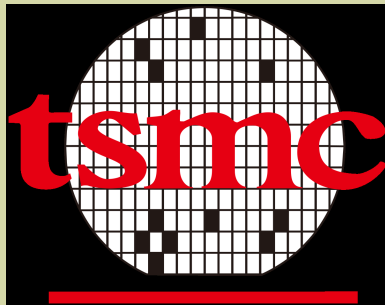
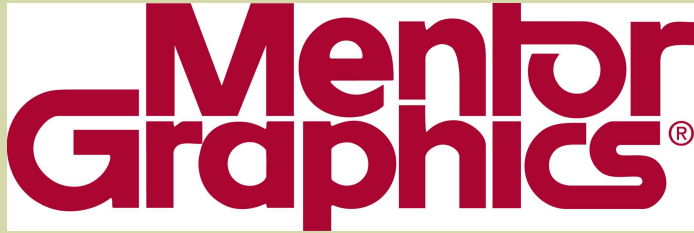
Google/SkyWater and the Promise of the Open PDK

Here is one solution (used at efabless):



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Commercial EDA Tool Vendors



Silicon Foundries

Google/SkyWater and the Promise of the Open PDK

Early open-source EDA tools

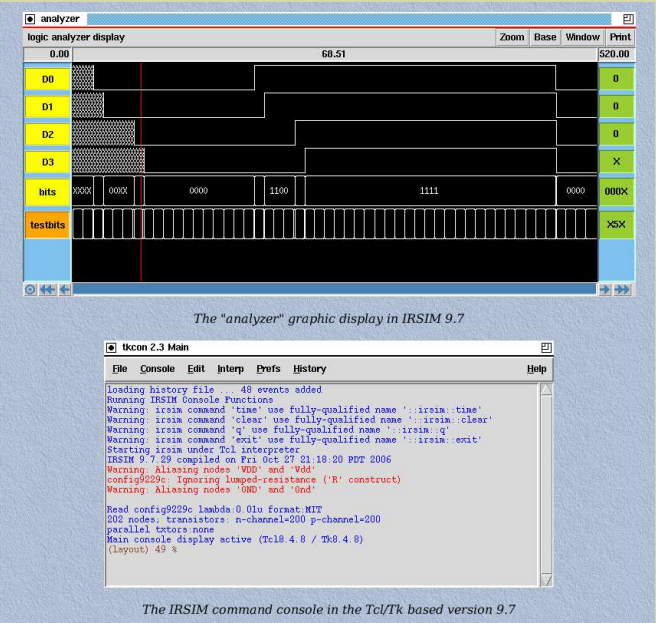
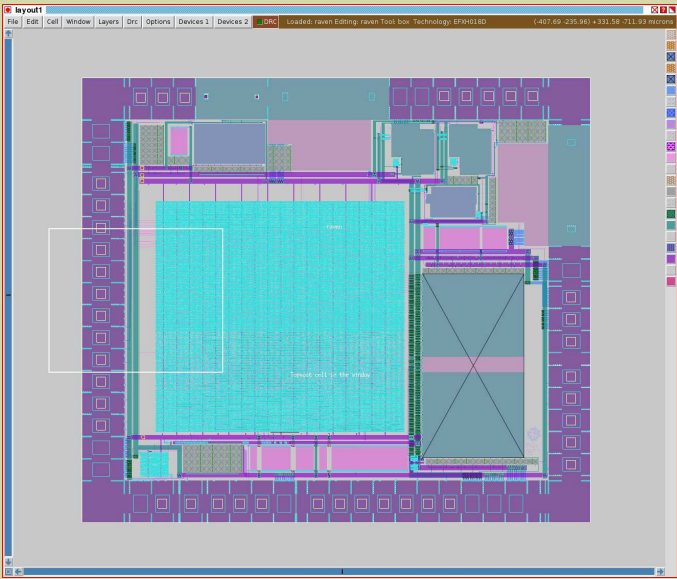
SPICE

Magic

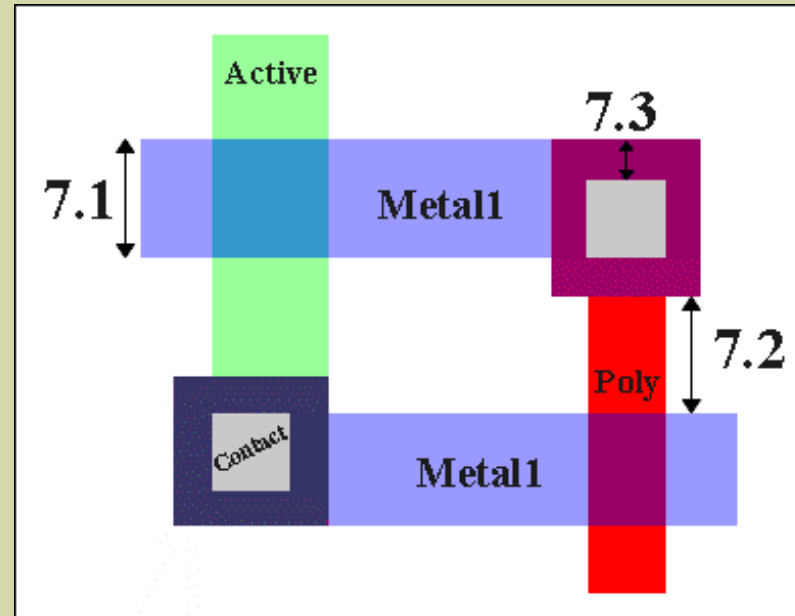
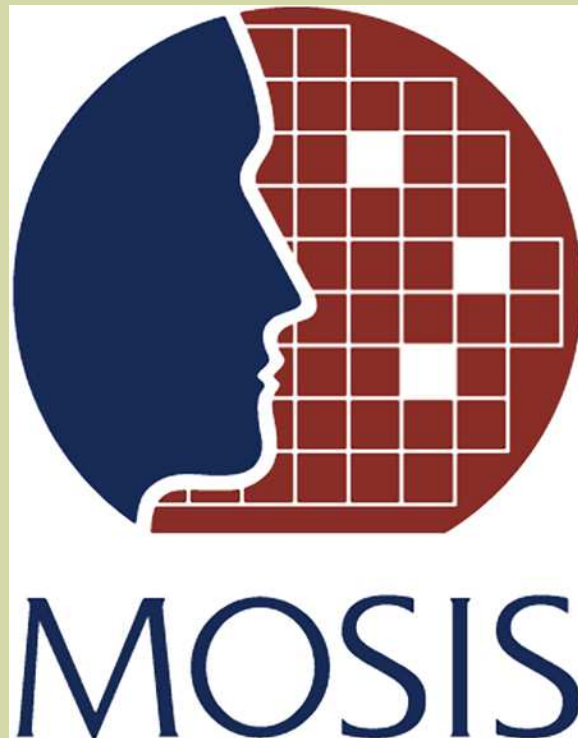
VIS/SIS

IRSIM

-
-
-

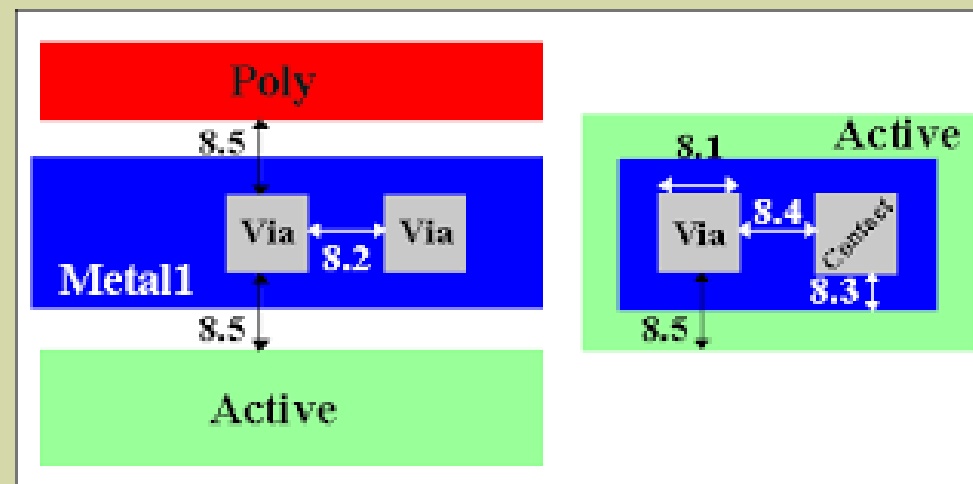


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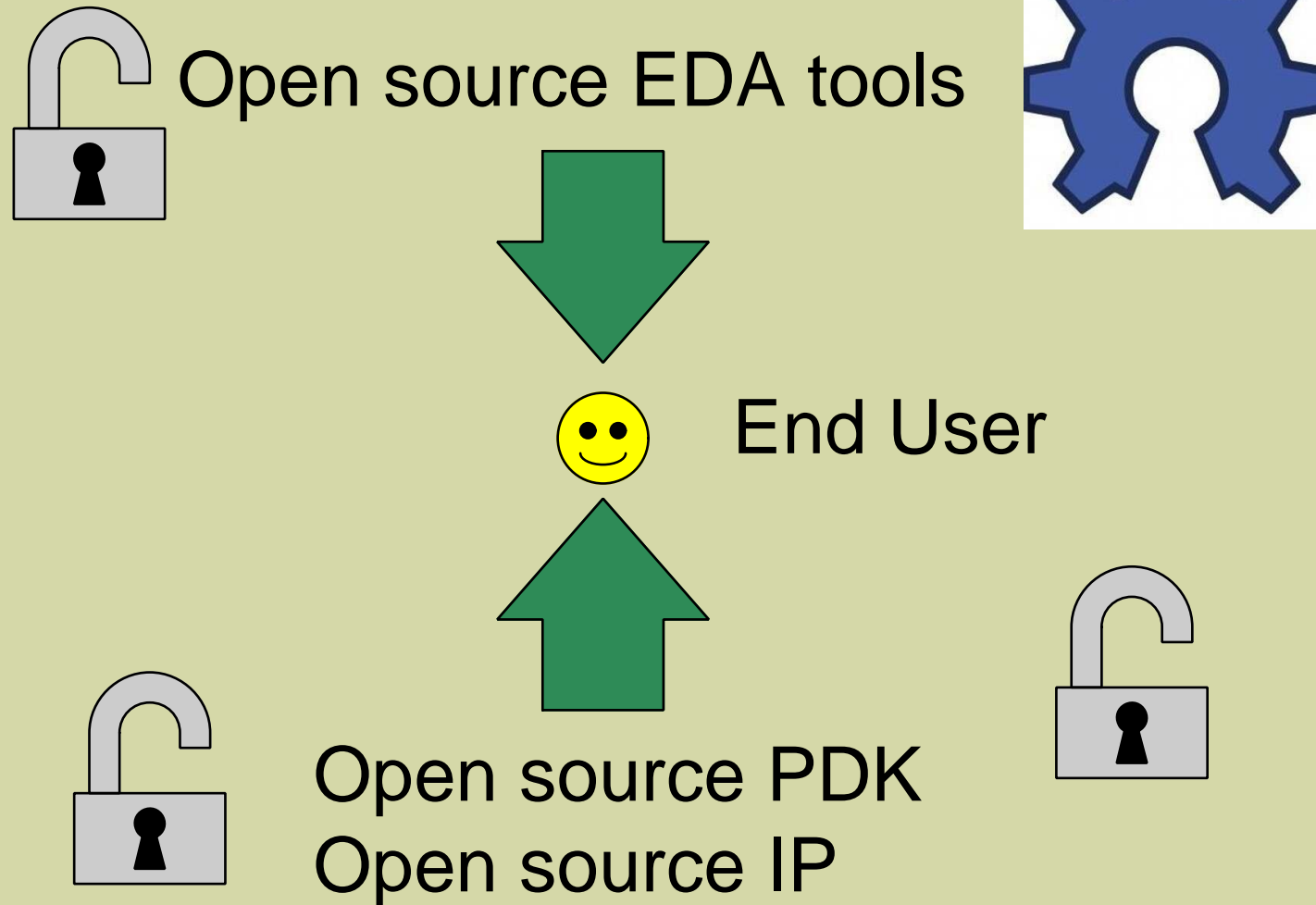
SCMOS

Scalable CMOS

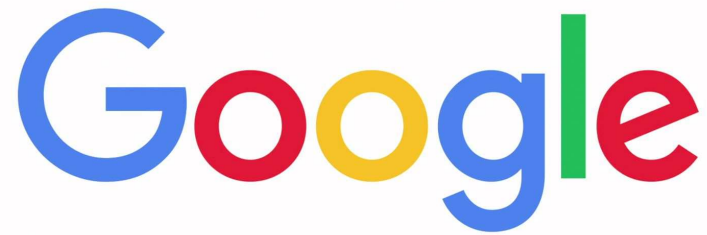


Google/SkyWater and the Promise of the Open PDK

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

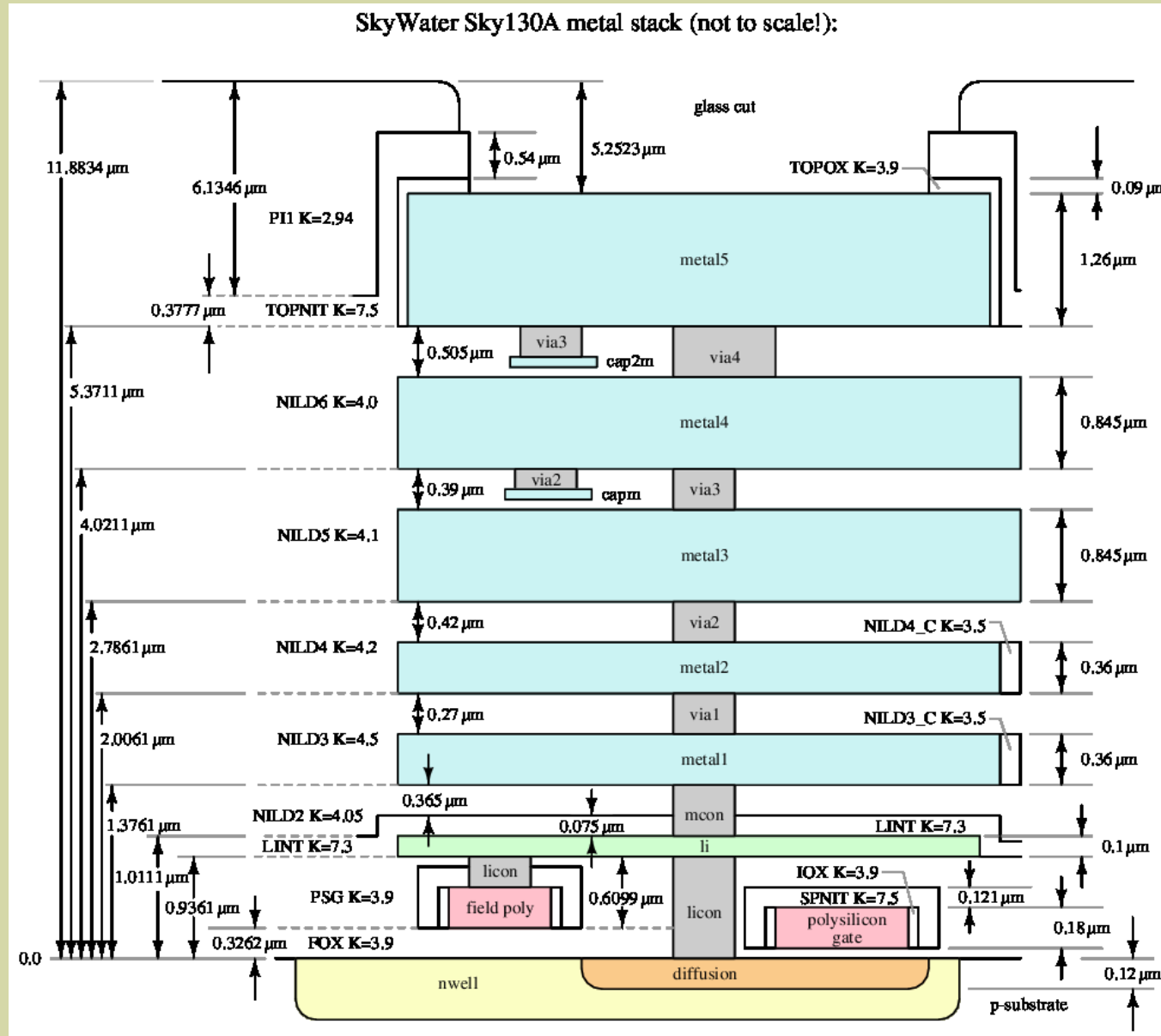


Join here:

<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

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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

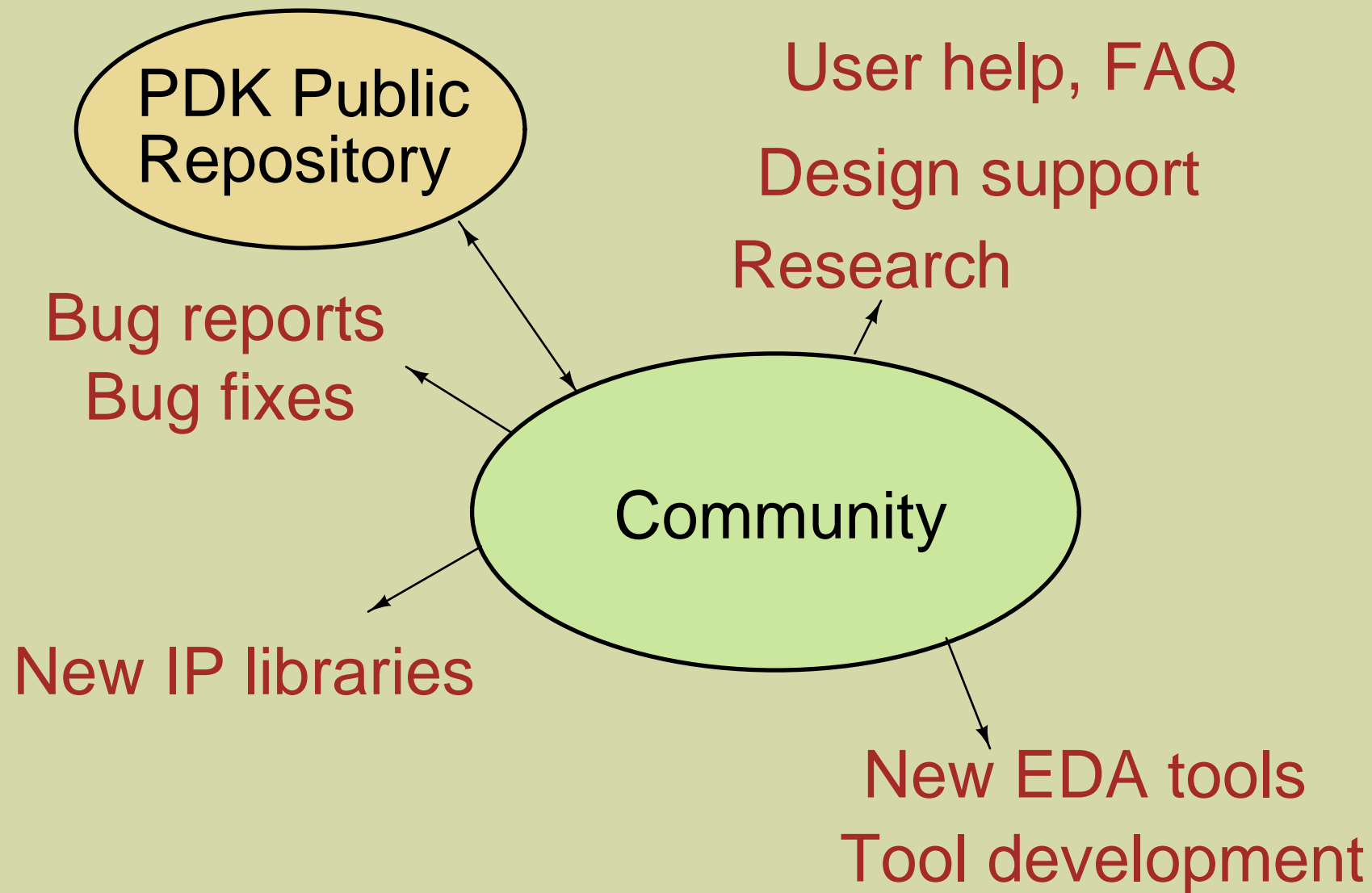
Voltage Regulator

Bandgap Reference

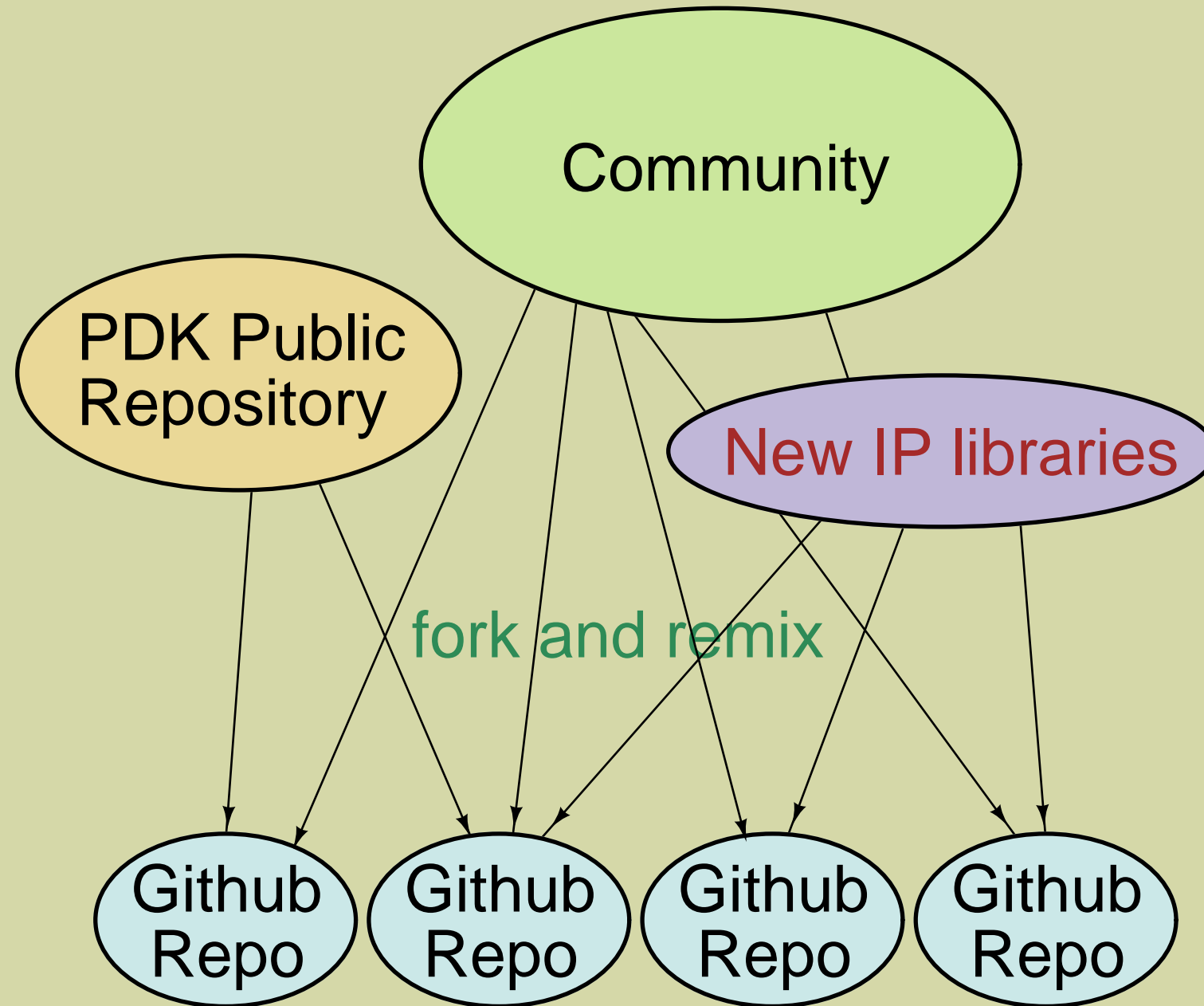
Power-on-Reset

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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

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The Downside is the Challenge:

Need new Open Source Tools

Need full integrated flows

Digital

Mixed-Signal

Analog

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Bug Reporting and Fixing:

Go to Issue Tracker

Post reproducible example

Patch gets pushed to repo

Pull patched repo



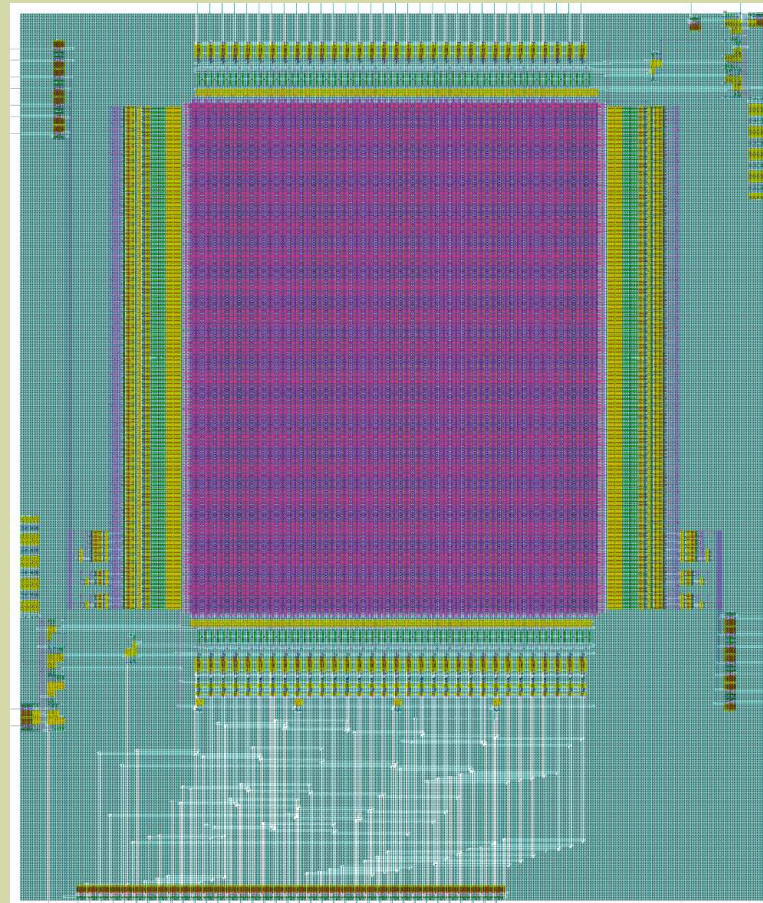
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Project Partners: UCSC

<https://github.com/VLSIDA/OpenRAM>

OpenRAM

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



2k × 32 SRAM

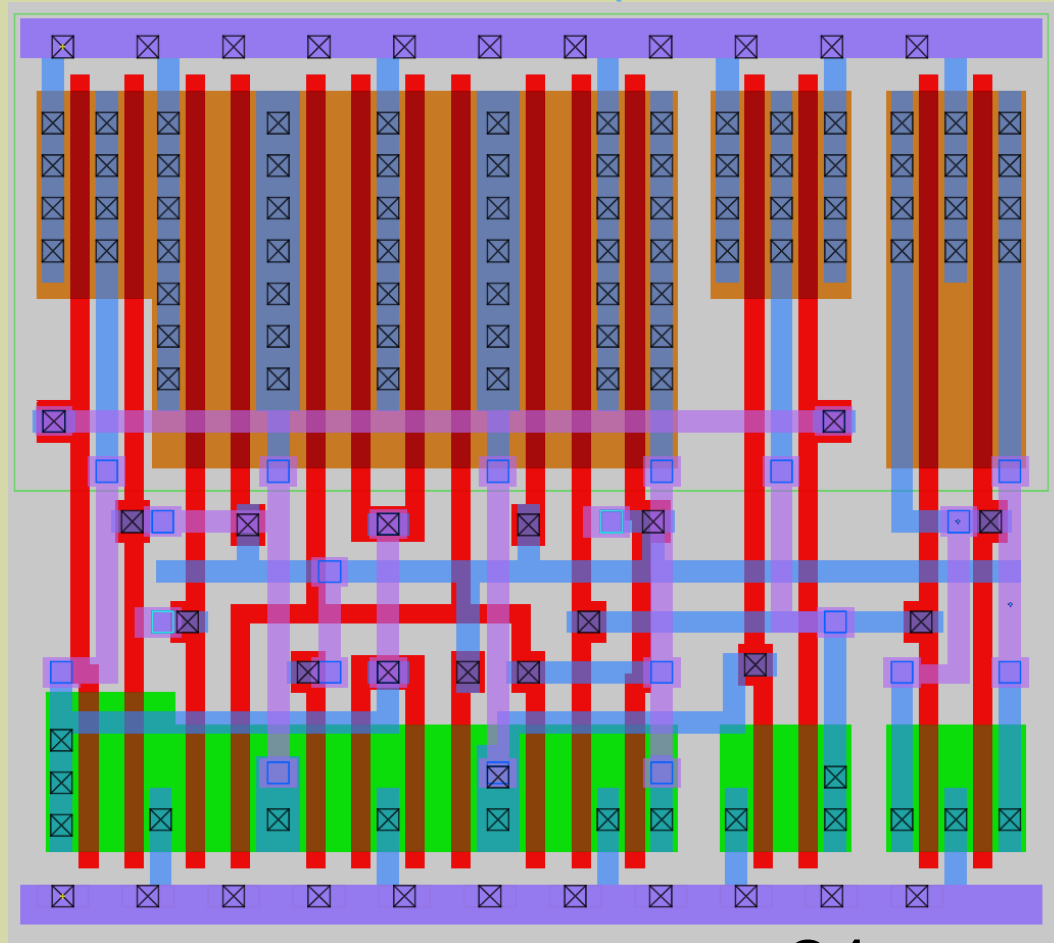
in SkyWater
130nm

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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

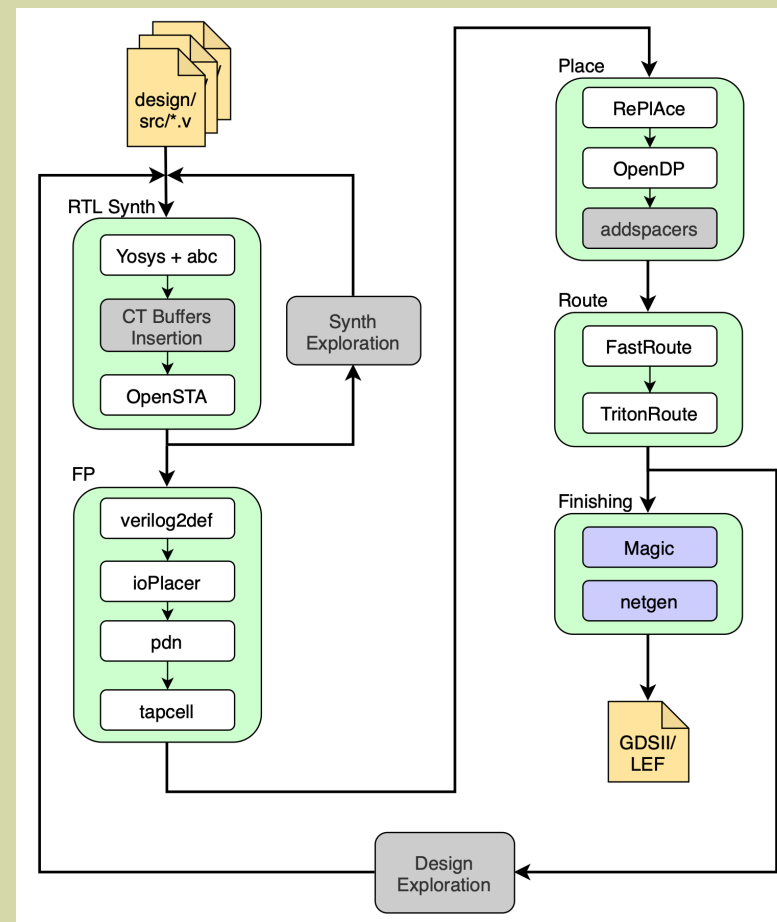
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Project Partners: AUC

<https://github.com/efabless/openlane>

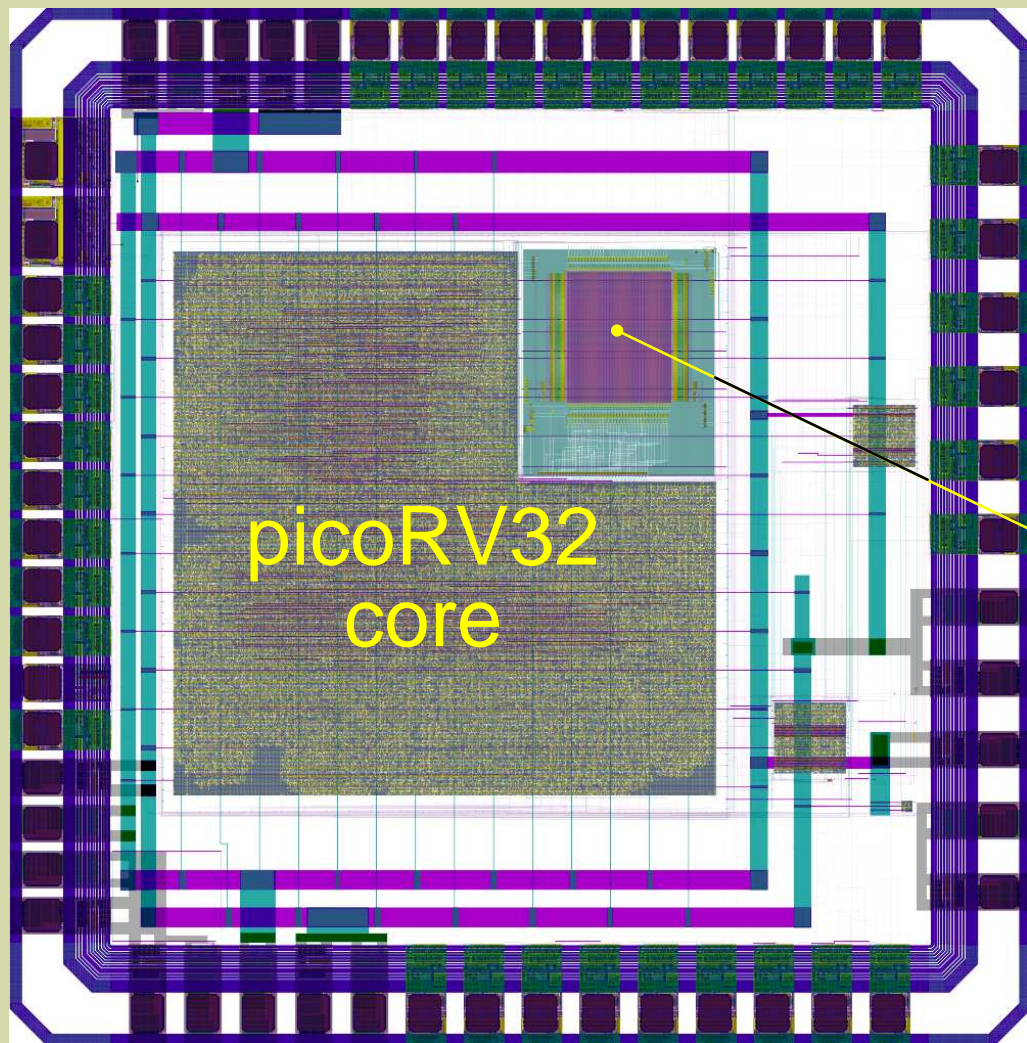
OpenLane

(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/)

openRAM
memory

synthesized, placed, and
routed with OpenLane

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Project Partners: Open Circuit Design

open_pdk

http://opencircuitdesign.com/open_pdk

Open_PDKs

Welcome

Download

Install

Release Notes

Code History

Reference

Tutorials

Wiki

Search

Mail EDA-dev

Email Archive

GitHub

OCD Home

Open_PDKs version 1.0 PDK Installer for open-source tools

Silicon foundry PDKs are notoriously non-standard, and files obtained from the foundry may end up in any possibly configuration of files and folders. In addition, silicon foundries are notorious among open source EDA tool enthusiasts for supplying user setups for commercial EDA tools and all but ignoring open source EDA tools. Open_pdk aims to mitigate the problem by defining a standard layout of files and directories for known open standard formats (e.g., SPICE, verilog, liberty, LEF, etc.) and for various open source EDA tools (e.g., magic, netgen, OpenROAD, klayout) using a Makefile system and a number of conversion scripts to ensure that for any process, all files needed by all EDA tools can be found in predictable locations.

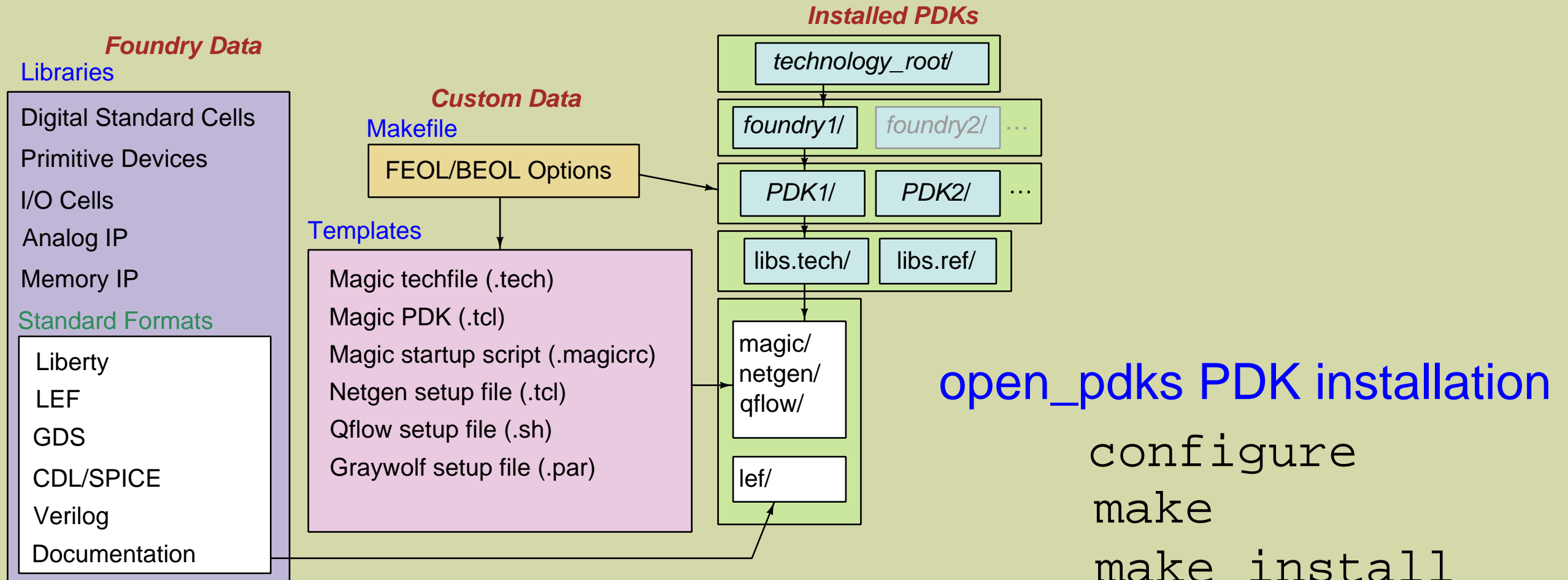
The scripts aim to be as general-purpose as possible to allow easy adaptation to new tools, formats, and foundries. Where foundry data is intractably unusable, custom install files can be added to overwrite or annotate vendor data as needed.

Open_PDKs is distributed with files that support the Google/SkyWater **sky130** open process description [github.com:google/skywater-pdk](https://github.com/google/skywater-pdk). Open_PDKs will set up an environment for using the SkyWater sky130 process with open-source EDA tools and tool flows such as magic, qflow, openlane, netgen, klayout, etc.

email: tim@opencircuitdesign.com

Last updated: July 5, 2020 at 3:55pm

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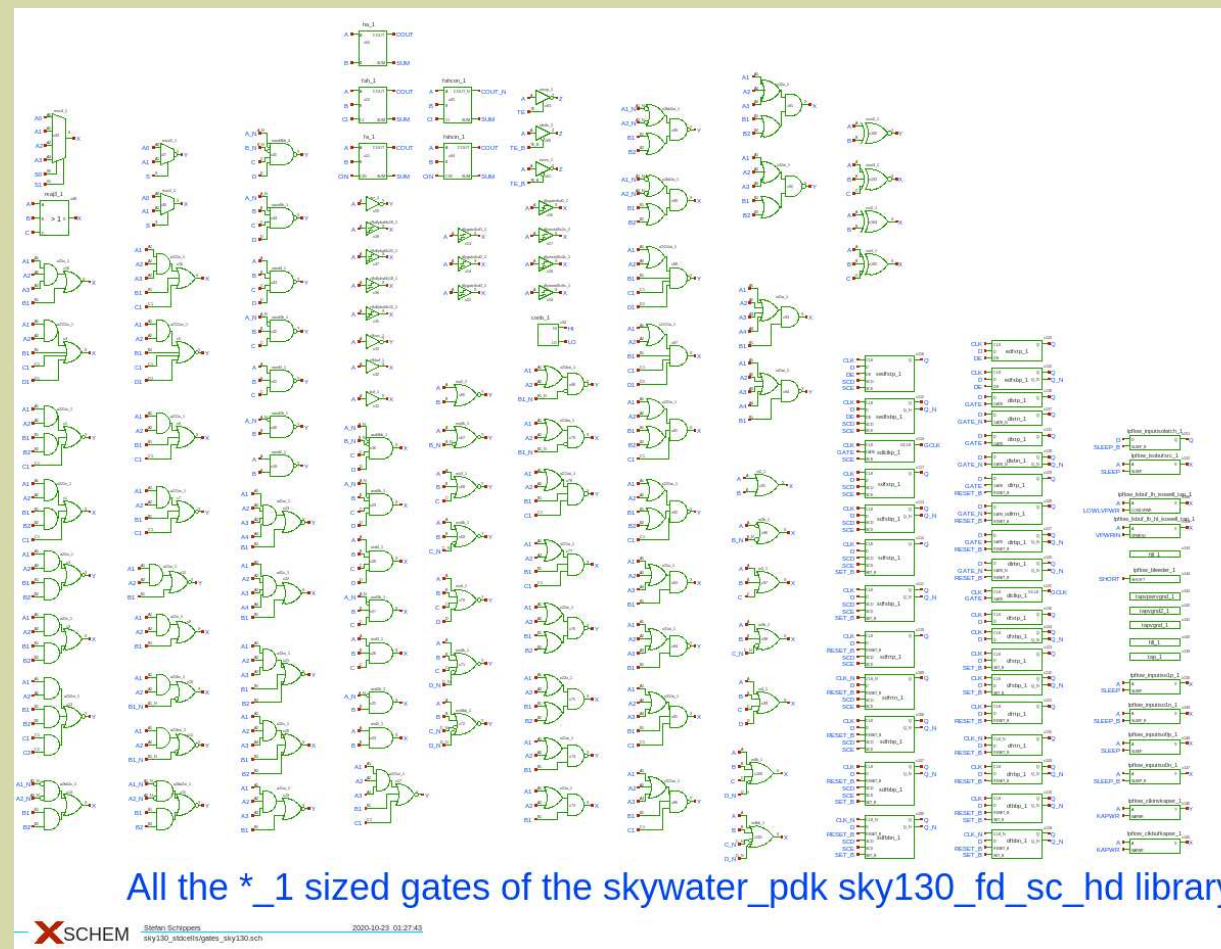
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Project Partners:

xschem

Stefan Schippers

<https://repo.hu/projects/xschem>



Google/SkyWater and the Promise of the Open PDK

New software projects:

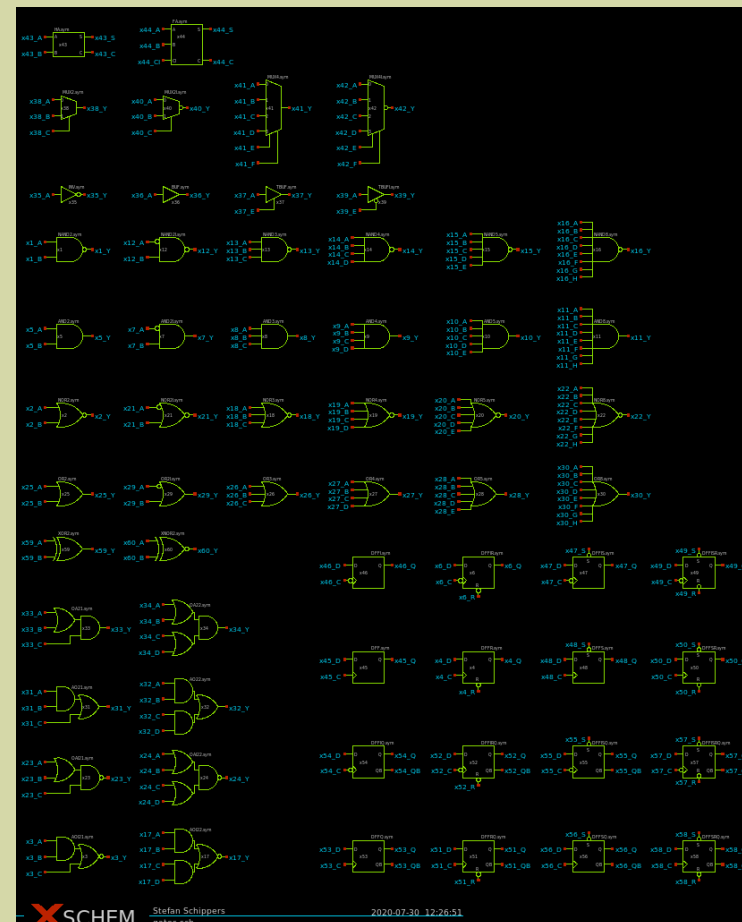
2020 summer internships at
efabless / Open Circuit Design

Arjun Rakheja

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

Automatic Symbol
Library Generation

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



WOSET at ICCAD

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November 5, 2020

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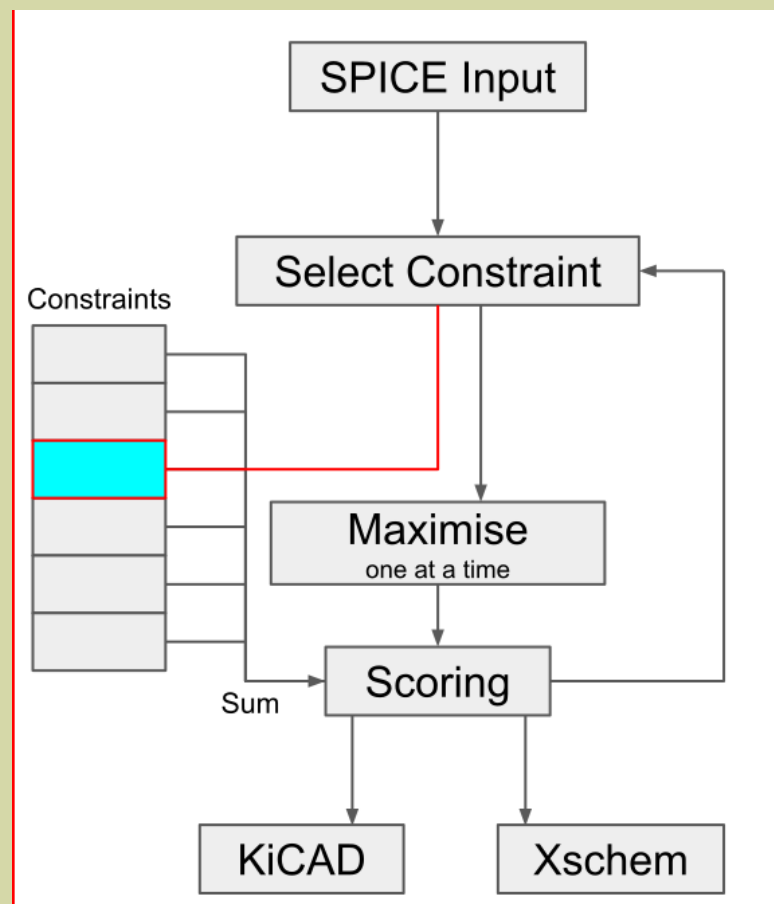
New software projects:

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

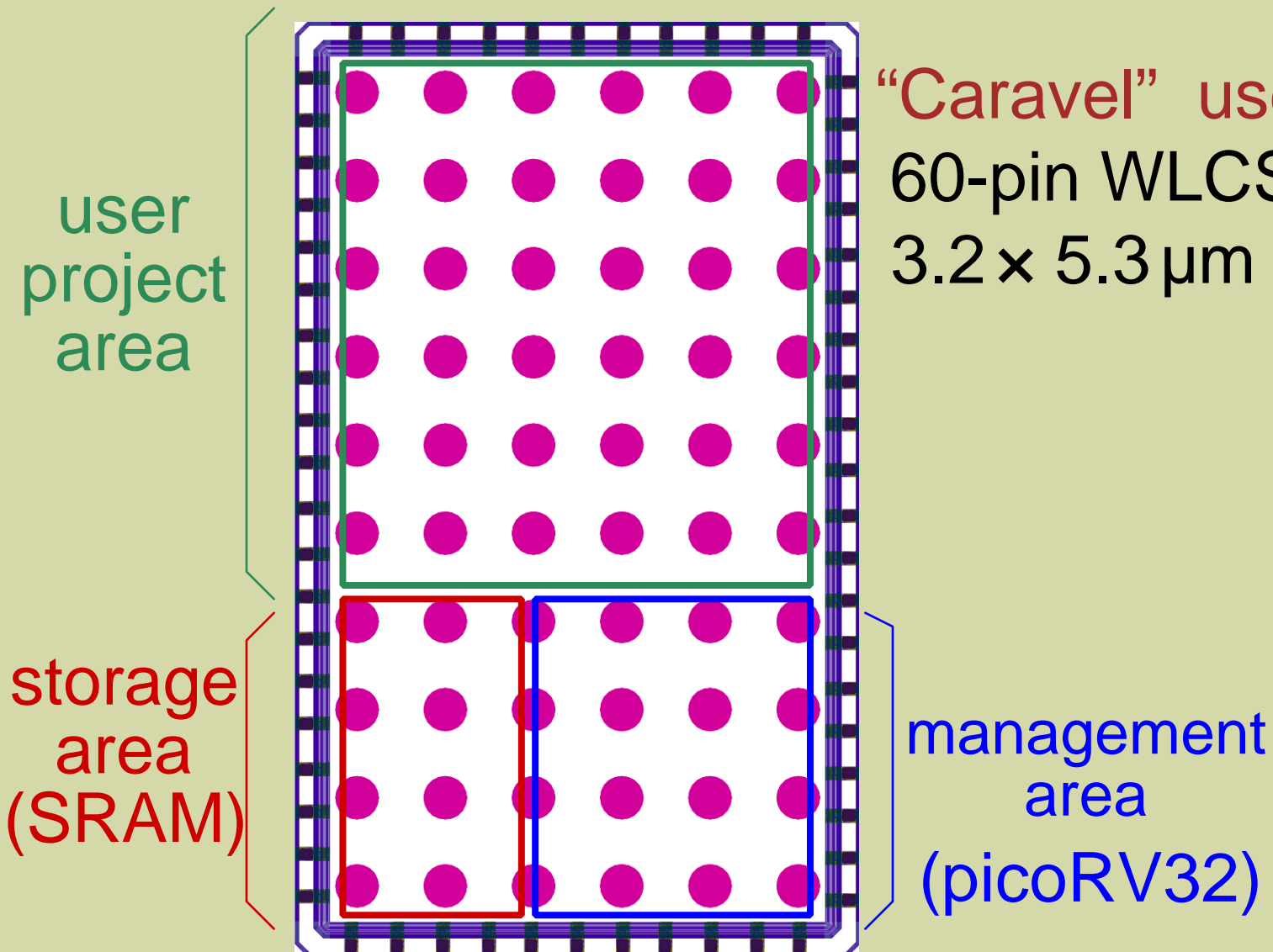
Experimentation Encouraged!

Submit designs to:



Google/SkyWater and the Promise of the Open PDK

The Google/SkyWater shuttle runs on efabless:



“Caravel” user project harness

60-pin WLCSP bump bond

$3.2 \times 5.3 \mu\text{m}$



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!

