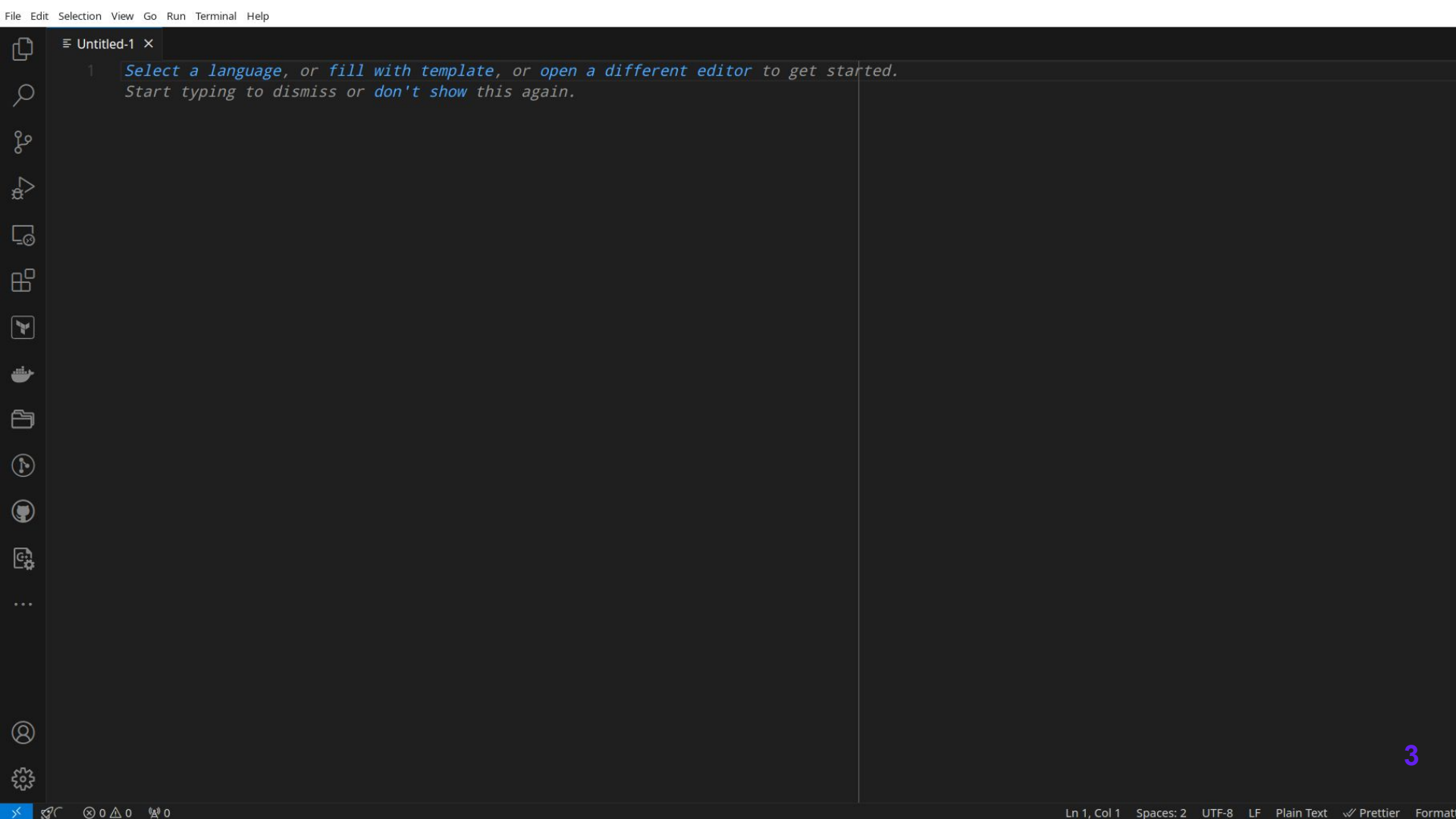
Free and Open Source Silicon is here to stay!

Philipp Wagner
FPGA Ignite Summer School
August 5, 2024

What's your crazy idea?


File Edit Selection View Go Run Terminal Help
Untitled-1
Select a language, or fill with template, or open a different editor to get started.
Start typing to dismiss or don't show this again.
3
Ln 1, Col 1 Spaces: 2 UTF-8 LF Plain Text Prettier

Our agenda

- How open source can help your crazy idea come true.
- How to do open source right.
- How the FOSSi Foundation can help.

About Philipp

lowRISC

opentitan

ocotb

open source initiative

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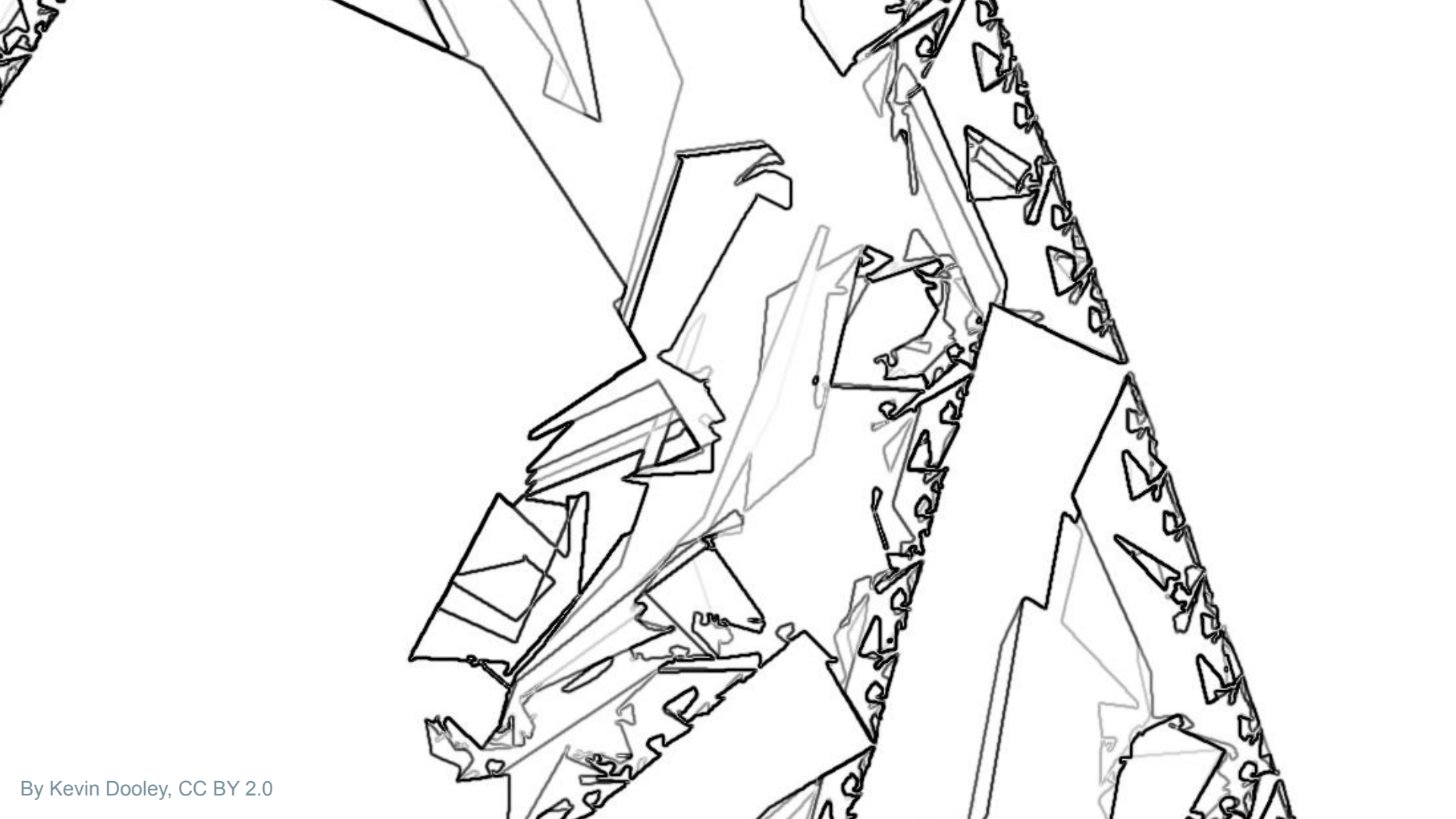
@imphil on GitHub
@MrImphil on Twitter

Defining Free and Open Source: The four fundamental freedoms

- The freedom to **run** the program as you wish, **for any purpose**.
- The freedom to **study** how the program works, and **change** it so it does your computing as you wish.
- The freedom to **redistribute** copies so you can help your neighbor.
- The freedom to **distribute copies of your modified versions** to others.

Free and Open Source licenses add color and legalese to these freedoms.

Interior view - Portland Art Museum - Portland, Oregon, USA., CC0



Building blocks

Frontend

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Just like programming

“Programming languages”	“All the other stuff”
High-Level Synthesis (HLS)	Test Frameworks
High-Level Languages	Build tools
SystemVerilog and VHDL	Developer productivity
Netlist	Simulators

Hardware description

- **(System)Verilog**
- **VHDL**
- **BlueSpec (Verilog/Haskell)**
- **Python-based**
  - Migen
  - Amaranth HDL
  - MyHDL
- **Based on functional programming languages**
  - Spinal-HDL (Scala)
  - Chisel (Scala)
  - Clash (Haskell)
- **CIRCT: LLVM**

Reuse and integrate

- LiteX
- GitHub
- (OpenCores)
- …

What can we do with a logic design?

- Verify it
- Document it
- Make it look pretty
- Simulate it
- Run it on an FPGA

Simulate it

GHDL

NVC

VERILATOR

Verification frameworks

SymbiYosys

Build and run

- FuseSoC and Edalize
- VUnit
- bazel_rules_hdl
- HDLMake
- …

Developer productivity

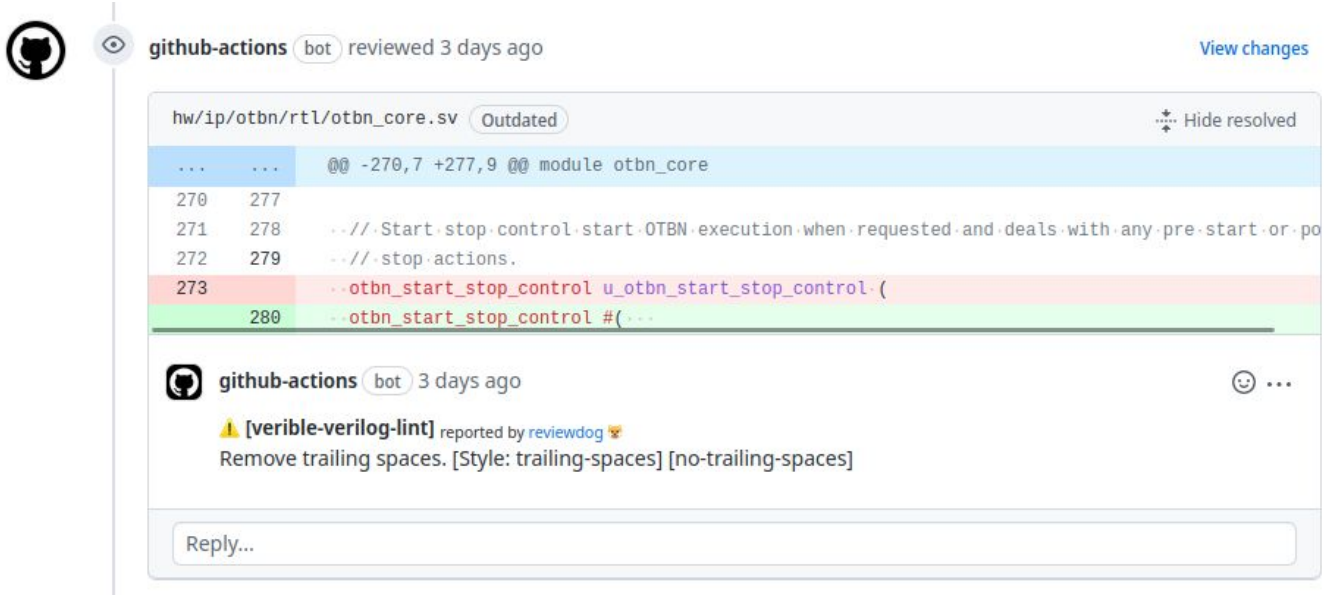
- **Verible: lint, formatter, code indexer, language server, and more**
  - Formatting based mostly on the lowRISC SV Style Guide
- **Verilator lint**
- **VHDL Style Guide (VSG)**
- **…**

Verilator lint

```
assign id_to_ping_d = (lfsr_state[PING_CNT_DW +: IdDw] >= NAlerts) ?
                      lfsr_state[PING_CNT_DW +: IdDw] - NAlerts    :
                      lfsr_state[PING_CNT_DW +: IdDw];
```

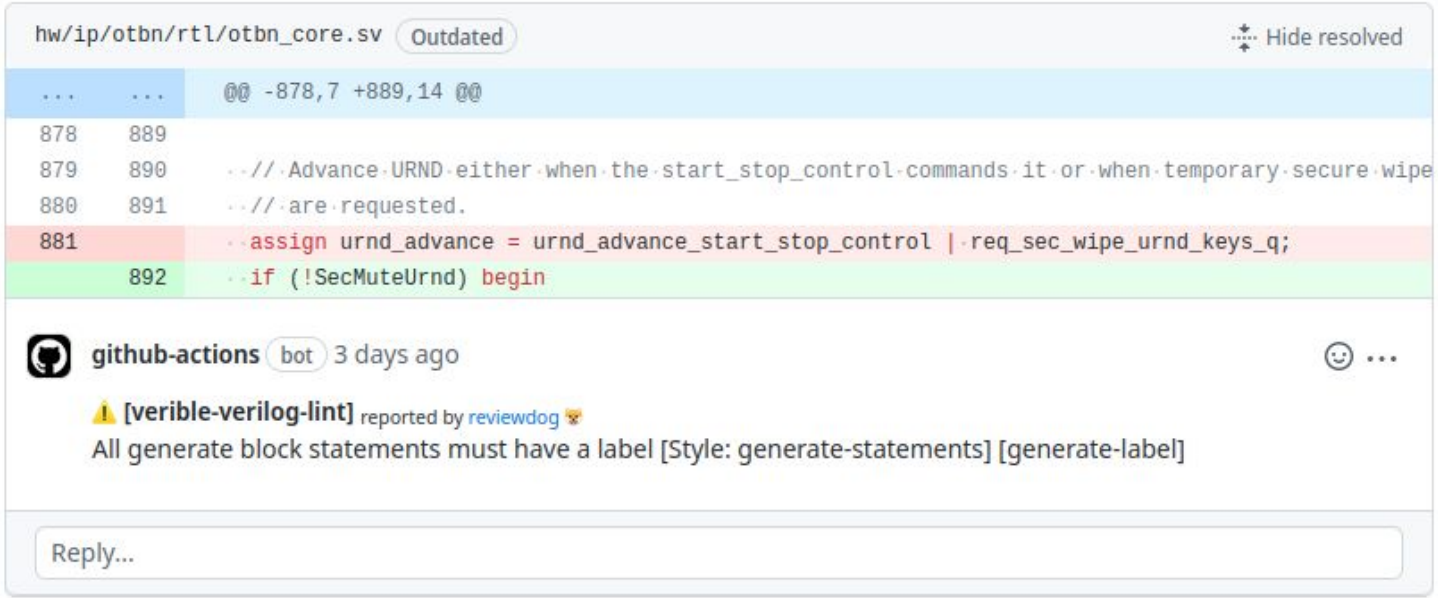
```
%Warning-WIDTH: ../src/lowrisc_ip_alert_handler_component_0.1/rtl/alert_handler_ping_timer.sv:131:58:
Operator GTE expects 32 bits on the LHS, but LHS's SEL generates 7 bits.

%Warning-WIDTH: ../src/lowrisc_ip_alert_handler_component_0.1/rtl/alert_handler_ping_timer.sv:132:57:
Operator SUB expects 32 bits on the LHS, but LHS's SEL generates 7 bits.

%Warning-WIDTH: ../src/lowrisc_ip_alert_handler_component_0.1/rtl/alert_handler_ping_timer.sv:131:70:
Operator COND expects 32 bits on the Conditional False, but Conditional False's SEL generates 7 bits.

%Warning-WIDTH: ../src/lowrisc_ip_alert_handler_component_0.1/rtl/alert_handler_ping_timer.sv:131:23:
Operator ASSIGNW expects 7 bits on the Assign RHS, but Assign RHS's COND generates 32 bits.
```

Automate reviews with Verible lint



Screenshot from https://github.com/lowRISC/opentitan/pull/17195

Automate reviews with Verible lint



Screenshot from https://github.com/lowRISC/opentitan/pull/17195

Summary

- The frontend is doing great.
- If we could only avoid re-inventing Verilog parsing.

Building blocks

FPGA

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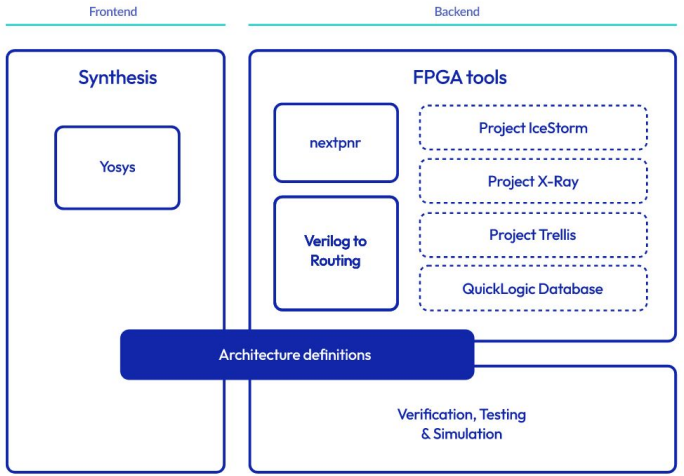
Run it on an FPGA

F4FPGA (formerly SymbiFlow)

F4PGA

	Project Icestorm	Project Trellis	Project X-Ray	QuickLogic Database
Basic Tiles:	✓	✓	✓	✓
- Logic	✓	✓	✓	✓
- Block RAM	✓	✓	✓	✓
Advanced Tiles:	✓	✓	✓	✓
- DSP	✓	✓	✗	✓
- Hard Blocks	✓	✓	✗	✓
- Clock Tiles	✓	✓	✓	✓
- IO Tiles	✓	✓	✓	✓
Routing:	✓	✓	✓	✓
- Logic	✓	✓	✓	✓
- Clock	✓	✓	✓	✓



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Building blocks

Backend

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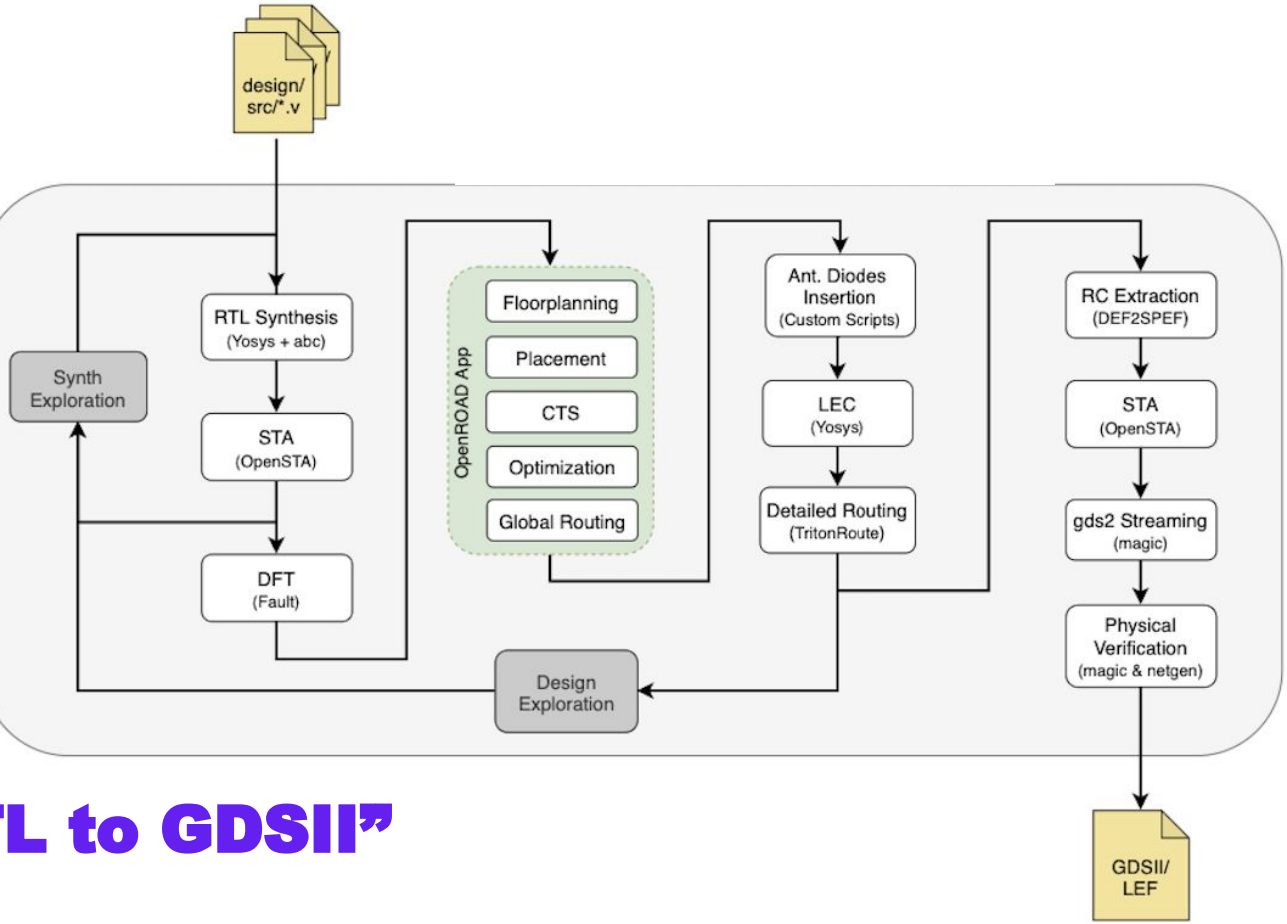
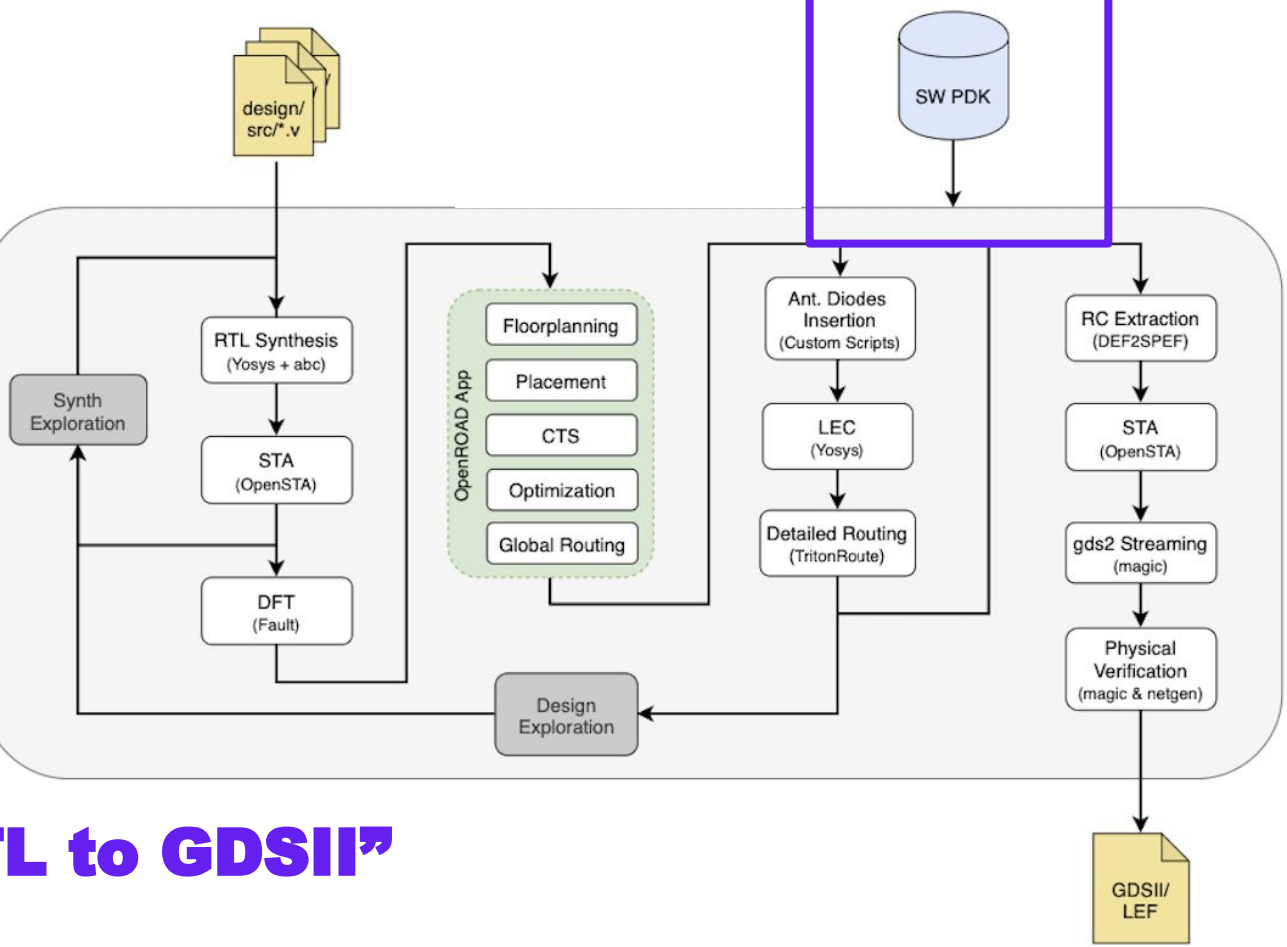

design/
src/*.v
RTL Synthesis
(Yosys + abc)
Synth
Exploration
STA
(OpenSTA)
DFT
(Fault)
OpenROAD App
Floorplanning
Placement
CTS
Optimization
Global Routing
Ant. Diodes
Insertion
(Custom Scripts)
LEC
(Yosys)
Detailed Routing
(TritonRoute)
RC Extraction
(DEF2SPEF)
STA
(OpenSTA)
gds2 Streaming
(magic)
Physical
Verification
(magic & netgen)
Design
Exploration
GDSII/
LEF

"RTL to GDSII"



“RTL to GDSII”

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Building blocks

The Process Design Kit (PDK)

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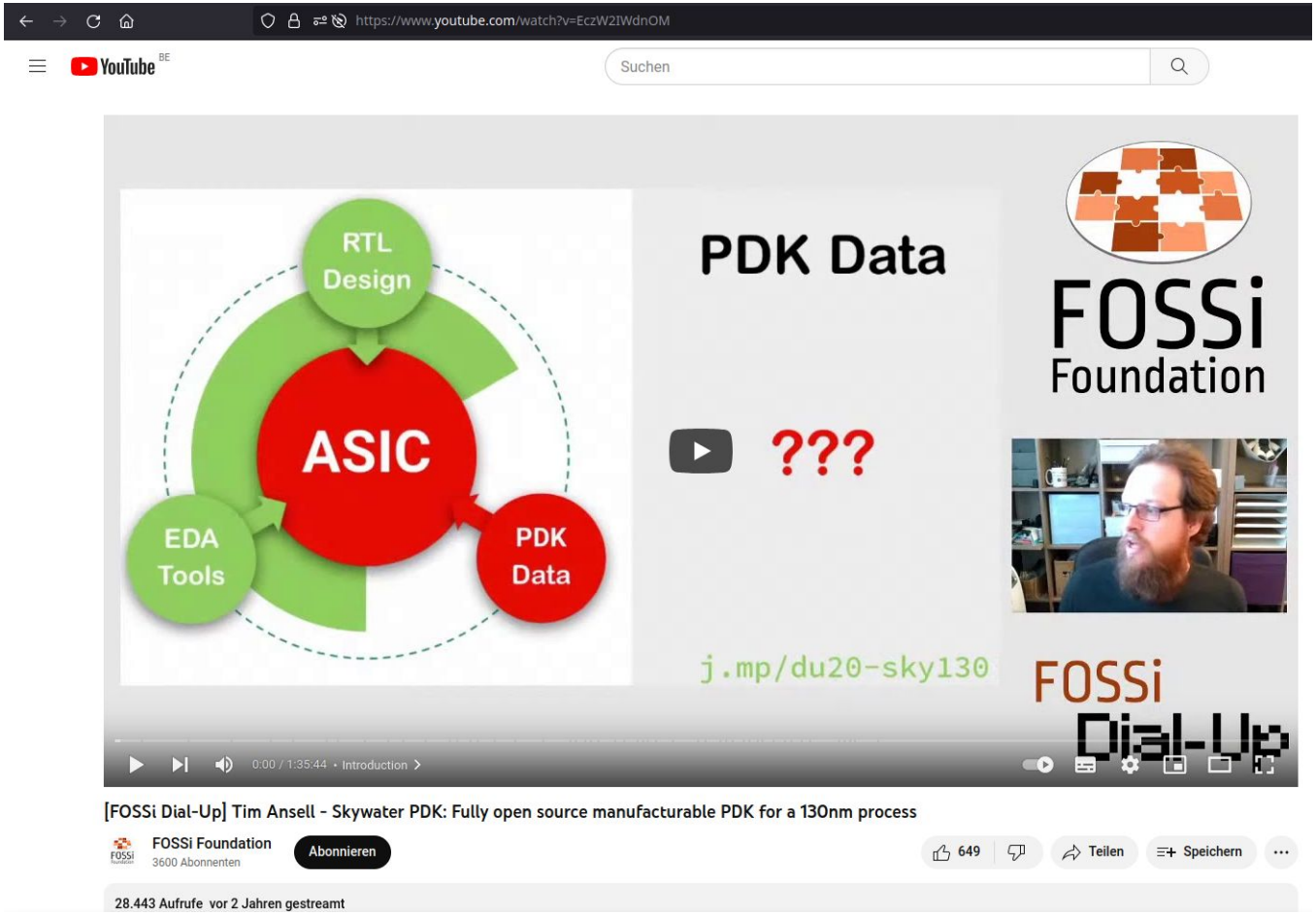

June 2020

Screenshot from https://www.youtube.com/watch?v=EczW2IWdnOM


SCALEO 600 X
AMD Athlon™ XP Prozessor 1700+
mit QuantiSpeed™ Technologie
266 MHz-Front-SideBus
Mainboard VIA KT 266
verfügbare Slots 3x PCI, 1x CNR, 3x AGP
AMD AthlonTM XP-Prozessor 1700+
mit QuantiSpeedTM Technologie
256 MB DDR-RAM Arbeitsspeicher
Doppelte-Daten-Rate
(Erweiterbar bis max. 1,536 GB)
40 GB Festplatte (5.400 U/min)
Praktische Frontanschlüsse:
• 2xUSB • Audio in • Audio out
16-fach-DVD
48-fach-CD-ROM-Laufwerk
Video Grafik-Karte VGA
64 MB nVIDIA Geforce 2MX 400
mit TV-Out
16x/12x/40x CD-Brenner
16-fach schreiben
12-fach wiederbeschreiben
40-fach lesen
TT Solo 1 SL
PCI Sound-Karte mit Wavetable-Software
• VSpace™ 3D Effekt • SoundBlaster/PRO kompatibel
3,5" 1,44 MB Diskettenlaufwerk
2 JAHRE GARANTIE
• 2 Jahre auf PC/
Hardware-Komponenten
• 48-h-Vor-Ort-Service
• Service-Hotline ist
365 Tage erreichbar
56 K internes Modem
mit Fax- und Anrufbeantworter-Funktion
1x 51/4" freie Einschübe,
4 USB-Schnittstellen (2 vorne/2 hinten)
Inklusive Bedienungsanleitung und sämtlichen Anschluss-Kabeln
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MULTIMEDIA-Tastatur:
Inklusive auswechselbaren Handballen-Auflagen in 3 Farben
3-Tasten-Wheel-Mouse:
Inklusive Mouse-Pad
Weitere Informationen erhalten Sie in unserem Handzettel
1998,–


ALDI informiert
...ab Mittwoch, 26. März
Der MEDION Titanium MD 8008 mit Intel® Pentium® 4 Prozessor 2,6 GHz
Einmalig
Der neue ALDI-PCXL Titanium MD 8008 von MEDION
intel inside
pentium 4
ECHTE 2,6 GHz
512KB Second Level Cache • Motherboard mit 3PCI-Steckplätzen • Grafik aufrüstbar durch AGP 8x Steckplatz • Arbeitsspeicher aufrüstbar durch einen freien Speichersteckplatz
Sony DVD-ROM 16x
Seagate 160 GB Festplattenkapazität Superschnell 7200 U/Min Ultra ATA100 Interface
ATI ATIRadeon9600TX 128MB DDR SDRAM 540 MHz Volle Hardwareunterstützung für DirectX 9
Samsung 512 MB DDR 333MHz Arbeitsspeicher 1 Modul - erweiterbar (max. 2 GB)
MEDION Stereo TV-, FM-Radio Karte Geeignet für: Kabel- und Antennenempfang (terrestrisch)
MEDION Funkfernbedienung Zur bequemen Steuerung der DVD-, TV-, Video-, CD-, Radio- und Fotofunktionen (Medion Power Cinema)
Firewire 3x Firewire/IEEE 1394 1 vorne · 2 hinten
DOLBY DIGITAL 6-Kanal Heimkinoton für das digitale Heimkinoerlebnis
DSL & Network Ready Netzwerkcontroller on board Fast Ethernet 10/100 MBit
MEDION 5 x USB 2.0 3 vorne · 2 hinten
MEDION 56K V.9x PCI Daten Fax Modem inkl. Faxsoftware und Telefon-Anschlußkabel OEM Version
Microsoft IntelliMaus® OEM Version
MEDION PS/2-Tastatur mit nützlichen Zusatztasten
DVD RW
DVD ROM
CONNECTXL
MEDION
Der Testsieger**
Pioneer DVD-Brenner + CD-Brenner in einem Gerät
4x DVD-R 2x DVD-RW
** Computerbild 26/2002. Unter 8 DVD-Brennern im Test schnitt der Pioneer Brenner als bestes Gerät mit der Note 2,8 ab.
15 IN 1
DVDs und Video-CDs brennen
Digitaler Videorecorder
Zeitversetztes Fernsehen
Riesige Festplattenkapazität
Musik-CDs kopieren und erstellen
Heimkinoton für Video-DVDs
Mehrere Bildschirme anschließen
Bilder in Kinoqualität
Radio über Internet und Antenne
Lesegerät für digitale Fotos
Praktische Anschlüsse vorne
Besonders leise durch AIR-XL
Internet über 56k Datenfax-Modem
Riesiges Software-Paket
Optimal spielen, arbeiten und...
Der MultiMedia Internet PC inklusive:
DVD-Brenner / CD-Brenner • Fernbedienung • Office PC • High Performance Spiele Center • DVD Dolby Digital Home Cinema System • Stereo TV Tuner • Stereo Radio Tuner • Digitaler Videorecorder mit Time Shift Funktion • Multifunktions Kopier Center • Netzwerk Power Station • Multifunktions MP3 Maschine • Music Juke Box Video / Bildbearbeitungsmaschine • Kommunikationscenter
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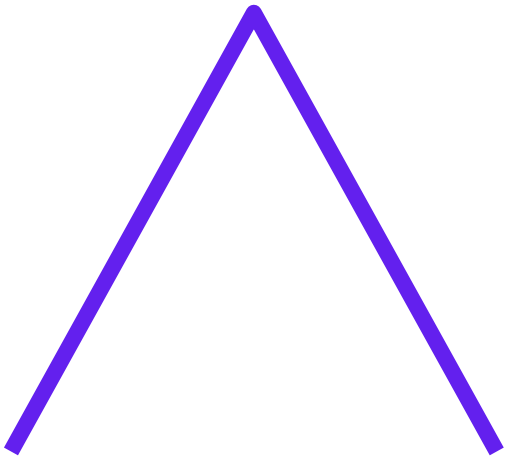
Get most out of open source

Open Participation

Enable everyone to **contribute**.



Allow everyone to **use** and **modify**

Open Source

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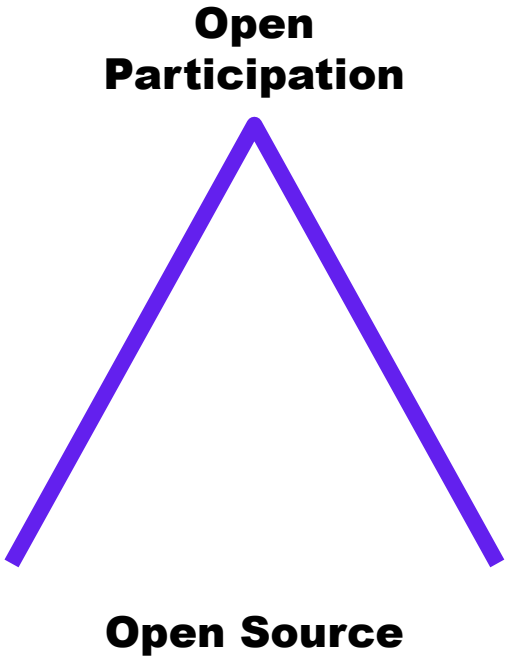
Open participation: your rewards

- **Attract contributors**
  - Code, docs, bug reports, testing, ports
- **Attract users**
  - Project activity is a major (perceived) quality indicator
- **Accessible and transparent “support channels” are important**
  - Help your business or group at university
  - If everyone can join easily, new hires or PhD candidates can as well.
  - Peer-to-peer help

Open participation

```
assign open_participation =
  (internal_dev == outside_contributor);
```

How do we get there?



+ Open communication

+ Build and test infrastructure

+ Tool access (reproducibility)

+ Documentation (design, process)

+ Clear licensing

All code, tests, scripts

The FOSSi Foundation

About FOSSi Foundation

The FOSSi Foundation exists to promote and protect the open source silicon chip movement. It actively encourages the community's growth and is helping to maintain the open spirit of the movement, through events, educational programmes and working groups. With an international membership of experts from academia and industry, it supports new open source initiatives and collaborations – offering free advice to governments and policy makers, corporations, academics and hobbyists. As a not-for profit organisation, the foundation is independent of any commercial interests and acts as a steward in support of open source projects which broadly benefit the open source silicon community. FOSSi is an acronym for Free and Open Source Silicon.

The FOSSi Foundation.

Join the community!

By Andrzej Otrębski, CC BY-SA 3.0

ORConf 2024

September 13 - 15, 2024
Goteborg, Sweden
https://fossi-foundation.org/orconf/2024

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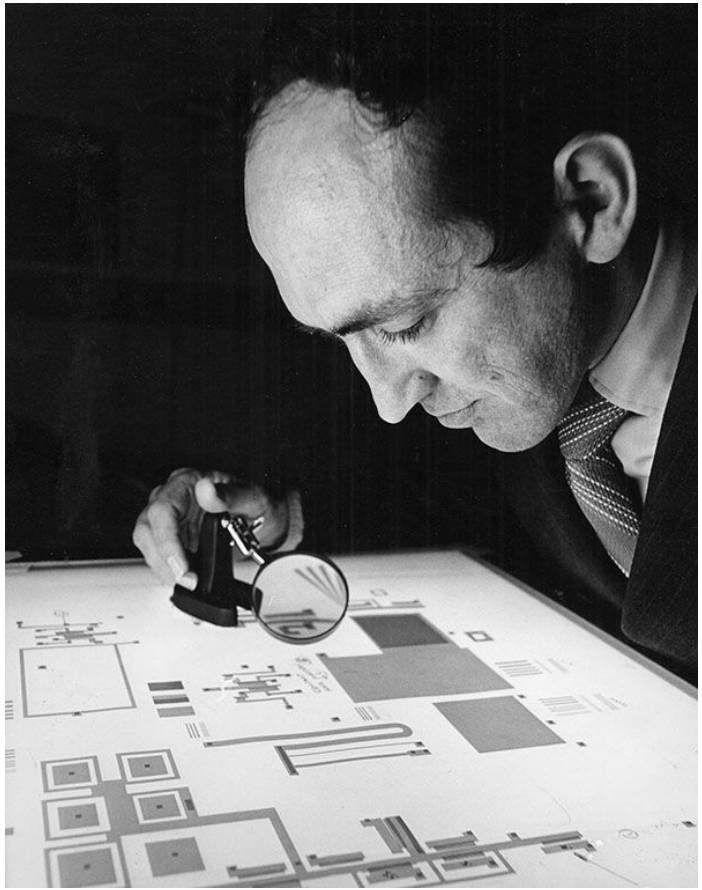
“There’s an end to scaling.

But there’s no end to creativity.”



Robert H. Dennard

The FOSSi Foundation.

There’s no end to creativity

- Unpredictable innovation.
- Simpler, more accessible, better tools.
- Democratized access! (part of it: cost)
- Revolutionize learning!

An atmosphere of excitement and anticipation pervades this field. Workers from many backgrounds, computer scientists, electrical engineers, and physicists, are collaborating on a common problem area which has not yet become classical. The territory is vast, and largely unexplored. The rewards are great for those who simply press forward.

C. Mead and L. Conway, Introduction to VLSI systems. Addison-Wesley Reading, MA, 1978.

Free and Open Source Silicon is a reality today.

Join the fun!