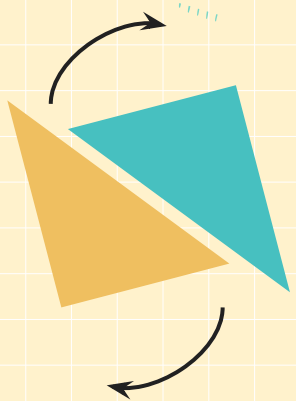
2023

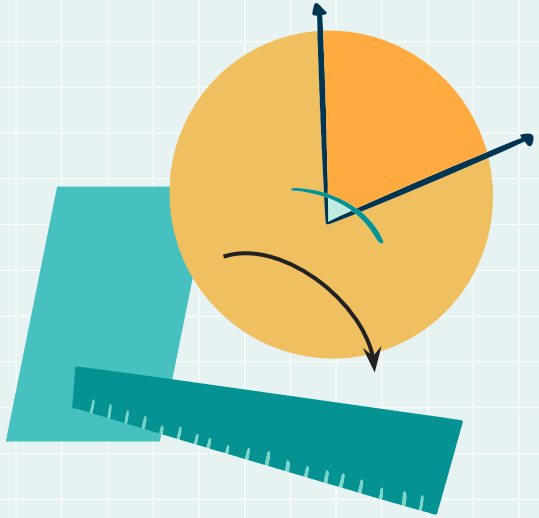
VLSI Design Seminar

Open-source Tools for FPGAs



What is Open-Source?

- Innovations that are jointly developed by different contributors.
- Commercial use allowed without royalty fees
- Mainly related to software development, but also connected to crowdsourcing



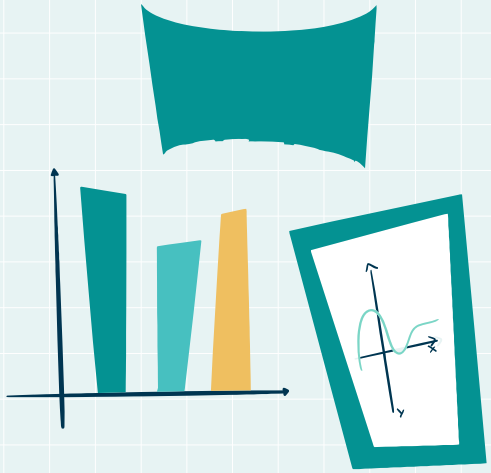
€65-95 Billion!

Impact on Europe's economy for every €1 billion invested

“The impact of open source software and hardware on technological independence, competitiveness and innovation in the eu economy,” 2021.

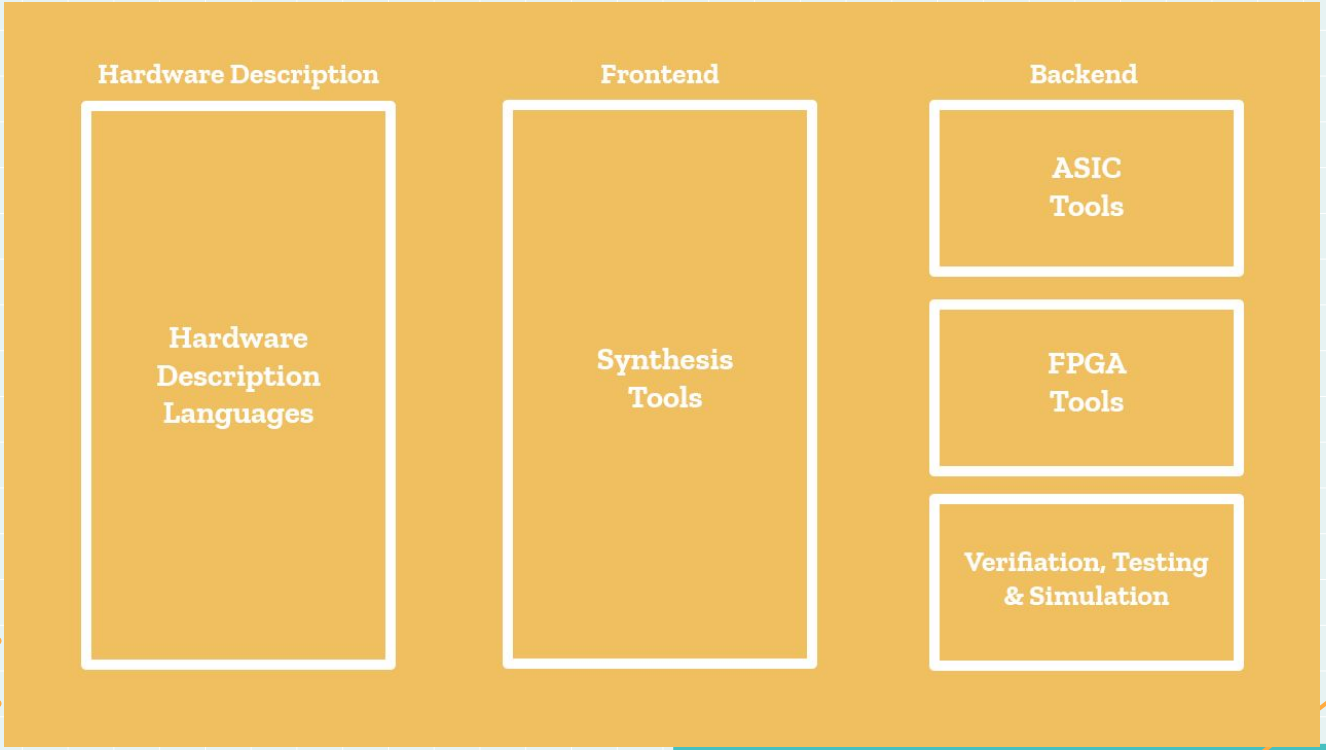
FPGA Overview

- Widely used in the creation of modern control systems
- Support the development process by enabling the reconfiguration of hardware/software throughout the device‘s lifecycle,
- Applications in different sectors of society, especially in military and aerospace equipment

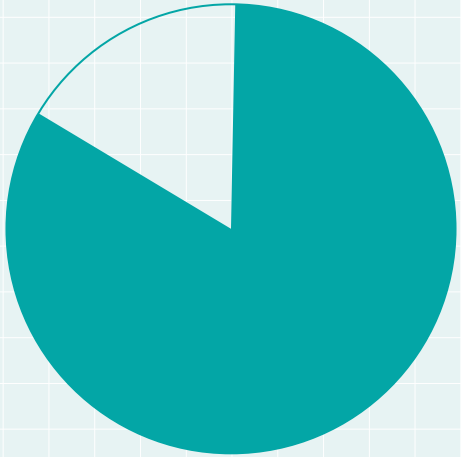


Electronic Design Automation Software

(EDA tooling)



FPGA Market Share



Xilinx

85%

Intel-Altera

Challenges & Consequences

Adaptation

Developers have to learn a new tool for every vendor

Secrecy

The majority of FPGA vendors keep the contents of their bitstreams in secrecy

Improvement

Hard time evaluating new architectural ideas.

High Costs

FPGA synthesis and place and route solutions

Is there any open-source FPGA toolchain?

If so, what are they doing?

What are the similarities and differences between open-source tools and proprietary counterparts?

01

Is there any open-source FPGA toolchain?

01

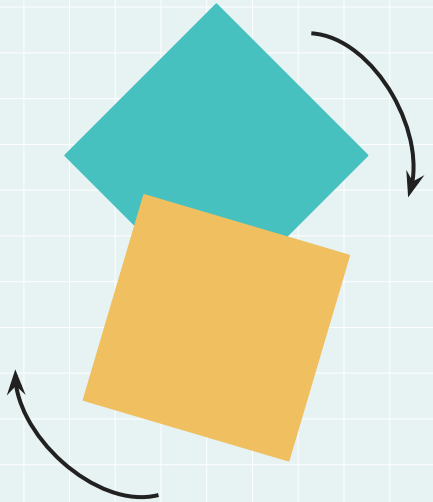
Is there any open-source FPGA toolchain?

YES.

OpenFPGA

Open-source framework that enables rapid prototyping of customizable FPGA architectures

- Automatically generates Verilog netlists describing a full FPGA fabric based on an XML-based description file
- Can auto-generate Verilog testbenches to validate the correctness of FPGA fabric
- Supports any architecture that VPR can describe, covering most of the architecture enhancements available in modern FPGAs



OpenFPGA

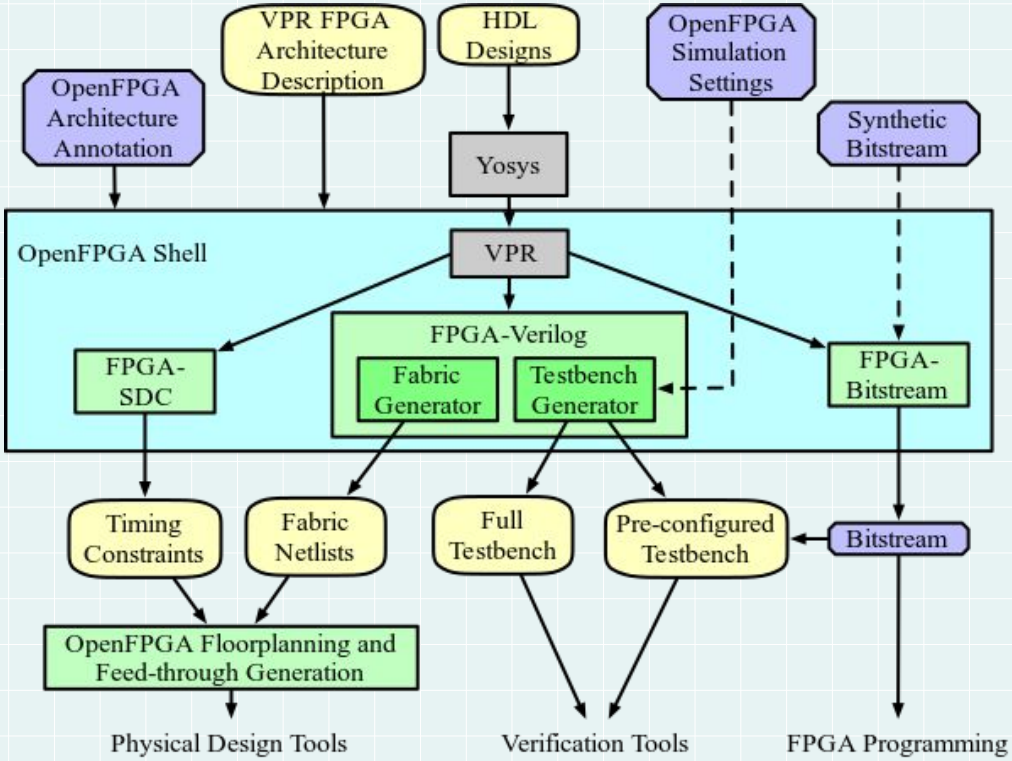
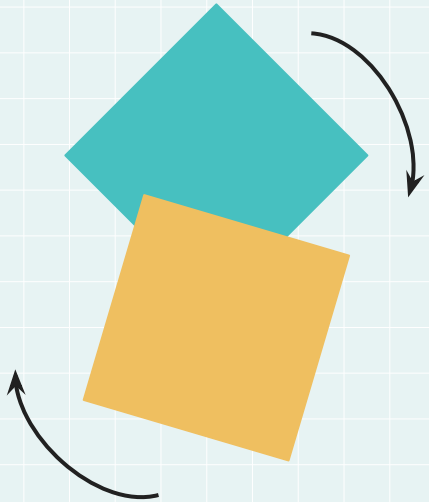


Image from https://openfpga.readthedocs.io/en/master/overview/motivation/

Princeton Reconfigurable Gate Array (PRGA)

Highly customizable, scalable, and complete open-source framework for building custom FPGAs

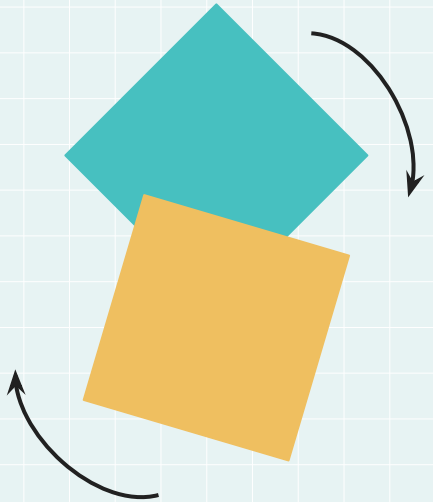
- Can generate synthesizable Verilog from user-specified FPGA architectures
- Provide an entire, auto-generated, open-source CAD toolchain for the custom FPGAs
- Supports the use of both standalone FPGA as well as an embedded FPGA



Archipelago

Open-source FPGA with tool flow support.

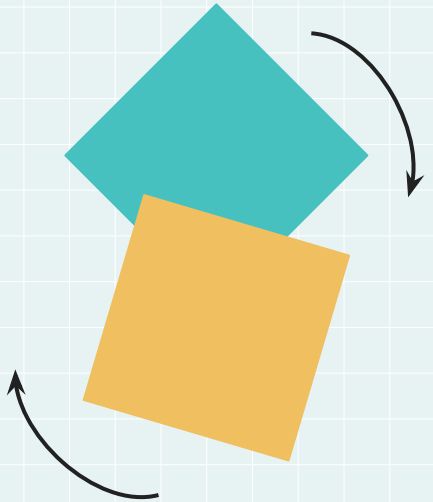
- Parameterizable and user-expandable FPGA with tool flow support



SymbiFlow

End-to-end FPGA synthesis toolchain that provides a fully open-source, multi-platform, and vendor neutral design tool option for FPGA developers.

- Can convert a Verilog design to a final bitstream.



Essential Tools

Yosys

Open-source Verilog synthesis tool.

Nextpnr tool

Place and route tool.

Versatile Place and Route (VPR)

Place and route tool. It supports netlists generated from tools such as Yosys

Icarus Verilog

Verilog compiler with a synthesizer and simulator.

Verilator

Verilog compiler limited to synthesizable Verilog or SystemVerilog code.

GHDL software

VHDL compiler and simulator

02

If so, what are they doing?

F4PGA

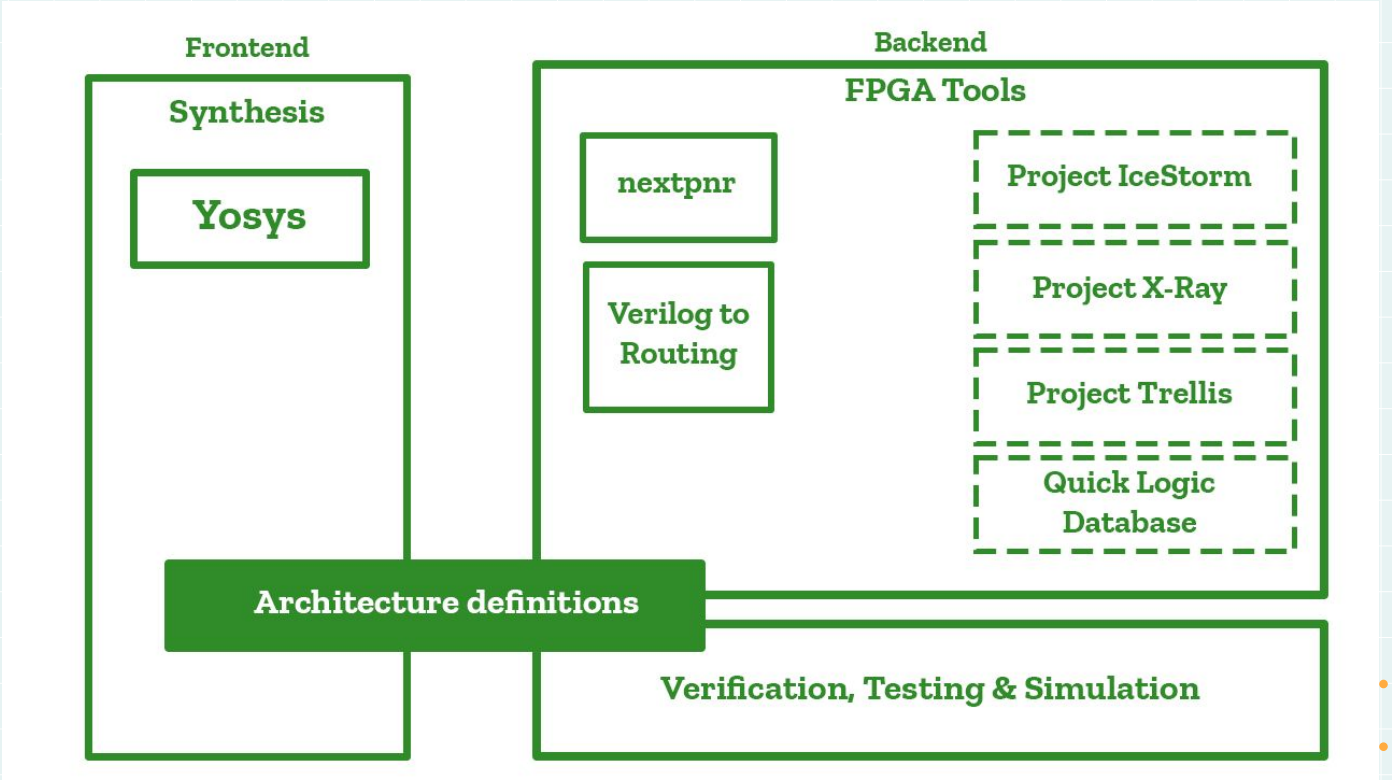
Started with IceStorm project, 2015, when a group of developers reversed-engineered and reconstructed the configuration file format for FPGA Lattice ICE40

F4PGA is an open-source **toolchain for the development of different vendors' FPGAs.**

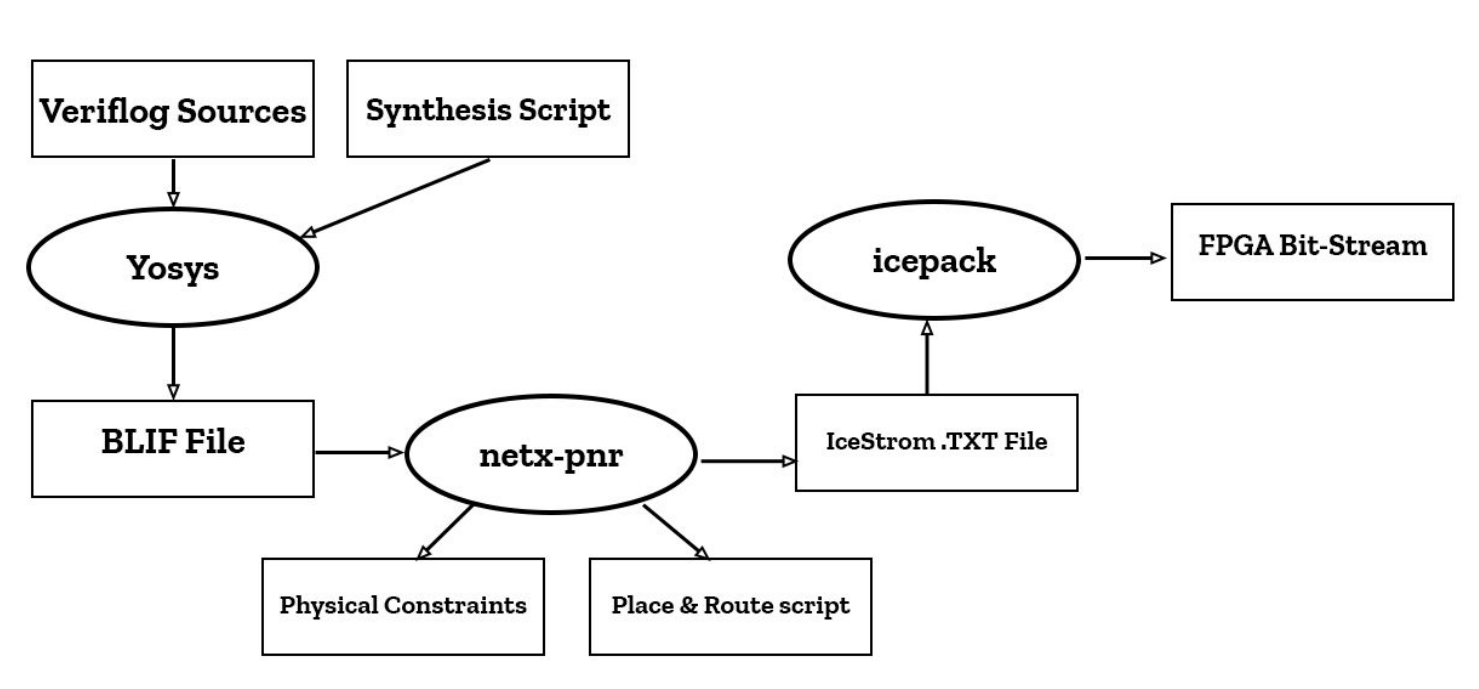
- Xilinx 7- Series
- Lattice iCE40
- Lattice ECP5 FPGAs
- QuickLogic EOS S3

Image from https://f4pga.org/

F4PGA


Frontend
Synthesis
Yosys
Backend
FPGA Tools
nextpnr
Verilog to Routing
Project IceStorm
Project X-Ray
Project Trellis
Quick Logic Database
Architecture definitions
Verification, Testing & Simulation

F4PGA


Veriflog Sources
Synthesis Script
Yosys
BLIF File
netx-pnr
Physical Constraints
Place & Route script
IceStrom .TXT File
icepack
FPGA Bit-Stream

CURRENT F4PGA PROJECTS STATUS

	Icestorm	Trellis	X-Ray	QuickLogic DB
Logic	yes	yes	yes	yes
BLock RAM	yes	yes	partly	yes
DSP	yes	yes	no	yes
Hard Blocks	yes	yes	no	yes
Clock Tiles	yes	yes	yes	yes
IO Tiles	yes	yes	yes	yes
Logic	yes	yes	yes	yes
Clock	yes	yes	yes	yes

03

What are the similarities and differences between open-source tools and proprietary counterparts?

RELEVANT RESULTS

1.

Competitive when reconfiguring FPGA-based control systems

2.

Competitive when designing reconfigurable computing for basic reactive robot behaviors

3.

Encrypted IP blocks is rarely supported in the present Open-source FPGA tools

04 Conclusion

By providing more information about proprietary device architectures, the cooperation of key FPGA stakeholders in the development of open-source FPGA tools can generate powerful and profitable results

References

- PRGA: An Open-Source FPGA Research and Prototyping Framework
- A Survey of FPGA Benchmarks
- The impact of Open Source Software and Hardware on technological independence, competitiveness and innovation in the EU economy
- Archipelago - An Open Source FPGA with Toolflow Support
- Open Hardware in Science: The Benefits of Open Electronics
- Open Source Software as Intangible Capital: Measuring the Cost and Impact of Free Digital Tools
- FPGA-based Control System Reconfiguration using Open-source software
- A Survey of Open Source Processors for FPGAs
- Reconfigurable Computing for Reactive Robotics Using Open-Source FPGAs
- OpenFPGA: An Open-Source Framework for Agile Prototyping Customizable FPGAs:
- SymbiFlow and VPR: An Open-Source Design Flow for Commercial and Novel FPGAs
- Introduction to Open Source FPGA Tools
- GCC for FPGA: SymbiFlow Open Source Toolchain

THANK YOU!

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