
picorio_doc Documentation

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1.1 Introduction

1.1.1 What is PicoRio

PicoRio is an open-source project stewarded by the [RISC-V International Open Source \(RIOS\) laboratory](#), a nonprofit research lab at Tsinghua-Berkeley Shenzhen Institute (TBSI). The RIOS Lab uses collaborative engineering from both academia and industry to elevate the RISC-V software and hardware ecosystem. In PicoRio, we create an open, affordable, Linux-capable RISC-V hardware platform to aid software developers in porting many modern programs that require Javascript or GPUs. PicoRio will build upon high-quality IPs and software components from expert industry engineers and academic researchers. PicoRio is not proprietary to any specific vendor and platform, and will have complete documentation that can help people to build quality products in a short amount of time.

1.1.2 Motivation

Need more than processors to build a system

- Large cost to license other IPs in SoC: cache, interconnect, graphics, camera ISP, etc.
- Need an attractive open-source platform to try new hardware ideas.
- Security and trusted execution are not complete without a full-system support.
- RISC-V hardware extensions: JIT runtime, vector, etc.

The community lacks affordable RISC-V hardware platforms that run a variety of software

- Few low-cost, software-capable boards for the long tail of developers.
- Developers won't spend \$1000 for a new hardware just for software development.

1.1.3 Highlights

- **Independently Maintained:** The RIOS Lab will be the solo nonprofit organization that governs the architecture development, ensures compliance, and will publish the design. The RIOS Lab will be the gatekeeper for both hardware and software, from SoC and firmware/drivers to high-level software and documentation. PicoRio will be vendor agnostic and not proprietary, and the RIOS Lab will work with academic and commercial organizations that will commit to its expansion and volume manufacturing.
- **Open Source:** PicoRio will open source as many components as possible, including the CPU and main SoC design, chip package and board design files, device drivers, and firmware. The exceptions are foundry related IPs (e.g., TSMC SRAM configurations), commercial high-speed interfaces, and complex commercial IP blocks like GPU. Nevertheless, our goal is to reduce the commercial closed source IPs for each successive release of PicoRio, with the long term goal of having a version that is as open as practical.
- **High-Quality IPs:** A major goal of the RIOS Lab is to develop open-source, industrial strength hardware IPs to help the RISC-V ecosystem catch up with those of the older, proprietary ISAs. Thus, PicoRio aims at a high-quality silicon release using open-source IP. The IPs will have gone through rigorous real tapeout verifications that meet industry quality. The openness of PicoRio will not come at the cost of lower quality IP blocks. In addition, we will open source our verification process, which will help to improve transparency and trustworthiness.
- **Modern Software Stack Support:** PicoRio utilizes a heterogeneous multicore architecture and is Linux-capable. We also designed PicoRio hardware to run modern managed languages such as JavaScript/WebAssembly as well as graphical applications like the Chrome web browser. At the RIOS Lab, PicoRio is also the hardware platform for several other open-source software projects, like the RISC-V ports for the V8 Javascript engine and the Chromium OS.
- **Low-Power and Low-Cost:** The target metrics of PicoRio are long battery life and low cost, which is a better match to RISC-V today, instead of high performance and large memory.

1.2 Project Roadmap

1.2.1 Three Phases of the PicoRio Development

We aim to incrementally improve PicoRio with each new release. We divide the development of PicoRio into three phases:

- **First Phase (PicoRio 1.0):** We include a basic 64-bit quad-core cache-coherent design (RV64GC) that runs full Linux. We have already booted a Chromium OS kernel in command line mode. A standalone version of Chrome V8 Javascript engine will run directly on the kernel. We expect an early beta release late this year. This “headless” version of PicoRio should be fine for software development.
- **Second Phase (PicoRio 2.0):** In addition to improving the v1.0 hardware, we are working with Imagination™ to include a complete display pipeline (including a GPU) with video encode/decode capabilities to run graphics intensive applications like web browsers.
- **Third Phase (PicoRio 3.0):** Building upon the v2.0 hardware, we plan to further improve the CPU performance to bring PicoRio to the level of a pad computer or laptop.

1.3 FAQ

1.3.1 How is PicoRio compared to Raspberry Pi?

Inspired by the Raspberry Pi, we propose the PicoRio project, whose goal is to produce RISC-V based small-board computers at an affordable price point. PicoRio has differences in the following aspects:

- **Open Source:** Unlike Raspberry Pi, which uses proprietary Broadcom SoCs, PicoRio will open source as many components as possible, including the CPU and main SoC design, chip package and board design files, device drivers, and firmware. Nevertheless, our goal is to reduce the commercial closed source IPs for each successive release of PicoRio, with the long term goal of having a version that is as open as practical.
- **Low-Power and Low-Cost:** The target metrics of PicoRio are long battery life and low cost, which is a better match to RISC-V today, instead of high performance and large memory. In contrast, Raspberry Pi uses more power hungry ARM processors. For example, the idle power consumption has risen from 0.4 Watts to 2.7 Watts in the latest version of Raspberry Pi.

This section describes the software projects which PicoRio supports. We put all projects in a dashboard, and list out the current developing status of them.

2.1 V8-RISCV

Welcome to the v8-riscv wiki

This is an on-going project to develop the RISC-V backend for the V8 JavaScript Engine. After a few months of intensive development, we have built a sufficient MVP (Minimal Viable Product) for the RISC-V64 port, which currently passes over 94% (15,000+) standard V8 test cases using v8-riscv64 simulated build. We have also established a sustainable porting methodology and development best practices that we feel confident invite a broader community participation. We welcome you joining our development effort. Plenty of supports are still needed for a complete and high-performing V8 on RISC-V.

This repo will be the community home for some time before the code-base is upstream to the V8 community. For general V8 information, see [V8 Dev](#). The rest of the wiki is specific to the RISC-V V8 backend.

RISC-V ISA specification is found [here](#), and RISC-V standard ABI can be found [here](#).

2.1.1 Getting Started

- Get the source
- Cross-compiled build (running on QEMU/HiFive)
- Simulator build (for developers running on x86)
- Run tests

2.1.2 Project Management

- Project roadmap

- Testing status
- Work groups

2.1.3 For Developers

- Setup VSCode
- How to contribute
- How to debug V8

2.1.4 RISC-V Backend Design Doc

- Understand V8 backend architecture
- How to add a new instruction
- How to develop a new backend

2.1.5 Community operation

- Join our Slack
- Attend our bi-weekly developer [Zoom Meeting](#)

| [Meeting Info](#) | [Description](#) | [|-|-|](#) | [Next meeting](#) | [08/19/2020 \(US\)](#) | | [Time](#) | [every other Wednesdays 6-7pm Pacific Time \(Thursdays 9am Beijing Time\)](#) | | [Meeting ID](#) | [876 4151 0603](#) | | [Passcode](#) | [714793](#) | | [Meeting agenda](#) | [Meeting agenda \(08/19\)](#) | | [Last meeting minutes](#) | [Meeting minutes \(08/19\)](#) |

- Content sharing

Projects	Devel- opment State	Project Description	Link
V8		V8 is a commonly used JavaScript engine in popular web browsers. PicoRio provides support for RISC-V V8.	https://github.com/v8-riscv/v8/
Chromium OS		Chromium OS is a open-source web browser with strong web application support and rich software ecosystem. This project is RISC-V port of Chromium OS, and is in development.	