RuyiSDK: Preparing for 1 million RISC-V software developers

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About me: Wei Wu (@lazyparser)

- TSC Member of RISC-V International (RVI) and RISE Project (rep ISCAS)
- BoD Member of CHIPS Alliance (rep ISCAS) and LLVM Foundation (rep myself)
- RISC-V ambassador (^o^)/
- **Founder of PLCT Lab** (2019-): Compilers, Runtimes, and Simulators
  - TARSIER Project (2022-2023): Make RISC-V a tier-1 support for FOSS.
- Core Organizer of RISC-V China Community (CNRV)
- Chair of HelloGCC(2013-) and HelloLLVM (2018-2022) Communities

What is PLCT Lab and TARSIER Project?

PLCT Lab is committed to

- becoming an open-source leader in the field of compilation technology.
- promote technological innovation in fundamental software areas.
- have management capabilities to maintain important open-source projects.
- cultivating more than 10,000 senior compiler engineers.

The Mission of TARSIER Project was

- make RISC-V the Tier-1 architecture for all open-source projects.
- port all popular Linux distributions to run on RISC-V PC and Laptops with OA suites.
- complete the porting of HPC computing software packages.

RISC-V is the future. We're seeing it.

In 2022, (almost) all the popular Linux distros support RISC-V. Linux Desktop is almost there.

Distros	Ubuntu	openKylin	Deepin	**openEuler**	OpenCloudOS	OpenWRT	OpenBSD	RT-Thread	Yocto
	Debian	Fedora	Gentoo	Arch Linux	FreeBSD	openAnolis	ChromiumOS	FreeRTOS	Buildroot

Lang & Runtime	C/C++/Fortran/Rust GNU GCC, Clang/LLVM	Java OpenJDK	JavaScript V8, NodeJS, Spidermonkey	Go / WASM Upstreamed	Dart Upstreamed	C# / .NET N/A

Very Good Support
Good Support
Basic Support
N/A

RISC-V is the future. We've already seen its potential.

Open Software/Standards Work!

Field	*Standard*	*Free, Open Impl.*	*Proprietary Impl.*
Networking	Ethernet, TCP/IP	Many	Many
OS	Posix	Linux, FreeBSD	M/S Windows
Compilers	C	gcc, LLVM	Intel icc, ARMcc
Databases	SQL	MySQL, PostgresSQL	Oracle 12C, M/S DB2
Graphics	OpenGL	Mesa3D	M/S DirectX
ISA	RISC-V	----------	x86, ARM, IBM360

- Why not successful free & open standards and free & open implementations, like other fields
- Dominant proprietary ISAs are not great designs

3

"Instruction Sets Want to be Free" Krste Asanovic, Professor of UCB

From compiler and OS engineers to app developers: two orders of magnitude

Now we need to get ready for the next 1 million RISC-V software developers

[1] https://octoverse.github.com/
[2] https://zhuanlan.zhihu.com/p/637787110

Why now? Why 2023-2025?

RISC-V computing devices for software developers:

a) RISC-V servers are powerful enough to do anything

b) RISC-V SBC and laptop prices drop into affordable range

c) Very cheap & tiny gadgets everywhere

Image Credits: Thanks to StarFive, Sophgo, Sipeed and Milk-V for providing product images

Why RuyiSDK: The Pain and Motivation

The initial idea (and pain) behind RuyiSDK

- The RISC-V instruction set is modular. This is good.
- However, if the user wants to try different combinations,
- So how much does it cost?
- Plus vendor-defined extensions?

The initial idea (and pain) behind RuyiSDK

- You need to compile the toolchain yourself, and maybe the Kernel, uboot, openSBI, etc.
- Vendors may have closed-source binary toolchains which provides some feature that open source solutions lacked.
  - and "vendor-specific" bugs and crashes
  - There are subtle differences in command-line arguments between different tools, and even between different versions of the same tool.
- Need to distinguish between native compilation and cross-compilation.
- Many downstream or out-of-tree patches.
  - Beware of versions of different system tools and libs!

The initial idea (and pain) behind RuyiSDK

Back to 2020, PLCT Lab was working on implementing a few ISA extensions like K, B, and V, etc.
We thought it wouldn't be that hard in the beginning…

RISC-V 中国峰会 · 第六天 · 本直播间是 PLCT RISC-V Day @ Shanghai 分会场
平头哥/DILIGENT分会场请移步 b/23228242 · Chisel 社区大会/CCC2021快去 b/22275404

我们仍未知道那些年立过的 FLAG 数量

—— F

If a customer wants to try out the effects and pros and cons of different instruction set extension combinations, what should he do now

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Source: PLCT OpenDay 2021,
co-located with The 1st RISC-V Summit China

Family Bucket Project: Allow users to test all combinations of instruction set extensions

全家桶计划：让用户可以测试所有指令集扩展的组合

- 如果一个客户想要尝试下不同的指令集扩展组合的效果和利弊，现在他需要怎么做？
  - 例如，要不要加 B 扩展？加 P 扩展还是 V 扩展？
- 源代码 → 编译器 → 模拟器 → FPGA
- 特权级 → Boot/Hyper/Kernel → 模拟器 → FPGA

Source Code → Compiler → Simulator → FPGA

Privilege Mode → Boot/Hyper/Kernel → Simulator → FPGA

当前状态：QEMU 有了公开的分支正在努力；GCC 也正在努力中

Current status: QEMU has a public fork and is working on it; GCC is also working on it

The Mission of RuyiSDK

- For non-system developers, it simplifies getting bogged down in implementation details as much as possible, while allowing developers to see the principles and processes behind it.
- Provide the unified development process, so that users can easily switch between different open source tools and vendor-customized toolchains.
- Simplify the environment construction of cross-compilation and native compilation.
- Provides a set of templates that can start with existing examples.

RuyiSDK architecture and components (simplified)

Developer's Laptop/Desktop. Native RISC-V

Aim to support all RISC-V devices available

RuyiSDK: How we get closer to our goal step by step

Developer's Laptop/Desktop. Native RISC-V

Aim to support all RISC-V devices available

RuyiSDK roadmap: what we have done in the past few years

2019 - 2021

- GCC & LLVM: Implement new instruction extensions, bug fixes, and backend optimizations for RISC-V.
- QEMU: Implement new RISC-V extensions. Provides simulation support for a variety of RISC-V devices.
- V8 (JavaScript Engine used in Chrome Browser and NodeJS): Ported V8 to RISC-V and actively maintaining it over the long term
- RISC-V Lab: Provide free RISC-V Farm services to developers in the global open source community.
- made a prediction that "there will be RISC-V Laptop by the end of 2022" and began to fill the gap in the desktop software ecosystem.

2022 - 2023

- The TARSIER project was officially launched, supporting more than ten popular Linux distributions and RTOS systems to better support RISC-V.
- Completed the RISC-V porting of LuaJIT, LibreOffice, Spidermonkey and box64.
- Contributed a series of performance optimization patches for RISC-V to the OpenJDK project.
- Led the effort to make RISC-V the official architecture of openEuler.
- Completed the first version of Ruyi Package Manager.

RuyiSDK roadmap: What we plan to achieve in 2024

1. Change release cycle to biweekly sprints to iterate features as quickly as possible.
2. More than 50 new RISC-V devices will be supported. (Currently support 3.)
3. support running ≥7 popular Linux distros. Support for openKylin and Gentoo will be added.
4. Supports SG2044 released in 2024.
5. Supports SG2380 released in 2024.
6. Provides multiple graphical IDE environments, including support for Eclipse and VSCode.
7. Serve ≥10,000 registered developers.

If you want to learn more about the development progress of RuyiSDK, you are welcome to watch the video replay of PLCT Lab OpenDay 2023 (most speakers use Chinese, but English comments and questions are accepted)
https://space.bilibili.com/296494084/channel/collectiondetail?sid=1968407

RuyiSDK Project is open-source

https://github.com/ruyisdk
https://github.com/plctlab

Currently, RuyiSDK has about 20 open source components (excluding IDE parts) being developed or integrated. It is expected that approximately 50 sub-projects will be open source by the end of 2025.

RuyiSDK Website

ruyisdk.org

Registration is scheduled to open on April 1, 2024.

Design Goal: RISC-V developers only need to visit the RuyiSDK website, and almost all the information needed for RISC-V development will be available here, whether provided directly by PLCT Lab or connected to a partner team.

Global Donation Program (Sponsored by Sophgo)

The global RISC-V equipment donation program launched by Sophgo and PLCT Lab is ongoing. If you are interested in RISC-V porting and development, please feel free to send me an email (wuwei2016@iscas.ac.cn).

RuyiSDK: A more ambitious operating system support matrix

	HOST		HOST				HOST	
	SG2042	CV1800B	TH1520	JH7110	K230	D1	U740	K210
	Pioneer Box	Milk-V Duo	LicheePi 4A	VisionFive 2	K230 Board	LicheeRV	Unmatched	K210
Arch Linux	Good	Basic	Good	Good			Good	N/A
Debian/RevyOS	Good	Basic	Good	Good		Good	Good	N/A
Fedora	Good	Basic	Good	Basic			Good	N/A
FreeBSD	CFT	CFT	CFT	CFT	CFT	CFT	Good	N/A
Gentoo	Good	CFT	Good	Good	Basic	CFT	Good	N/A
openAnolis			Good	CFT	CFT	CFT	CFT	N/A
OpenBSD	CFT	CFT	CFT	CFT	CFT	CFT	Good	N/A
openCloudOS	WIP	N/A		CFT	CFT	CFT		N/A
openEuler	Good	CFT	Good	Good	CFT	CFT	Good	N/A
OpenHarmony	WIP	N/A	WIP	WIP			WIP	N/A
openKylin	Good	N/A	Good	Good	N/A	N/A	Good	N/A
openSUSE	CFT	N/A	CFT	CFT	N/A	N/A	Good	N/A
Ubuntu	CFT			Good	Basic		Good	N/A
Zephyr	N/A						N/A	CFT
FreeRTOS	N/A	Good				N/A	N/A	CFT
RT-Thread	N/A	Good			Good		N/A	CFT
OpenWRT	N/A	N/A	Basic	Basic	CFT	Basic	CFT	CFT
ThreadX	N/A	CFT	CFT	CFT	CFT	CFT	CFT	CFT

第1回「RISC-V ソフトウェアの移植と最適化チャンピオンシップ」準備活動正式に開始いたします

https://rvspoc.org/ja/

- 2023年12月1日 – 2024年2月16日：申し込みと実施期間
- 2024年2月17日 – 2024年3月1日：主催者がチャンピオンシップの結果を再現し、勝者のリストを公開
- 2024年4月初（日程未定）：第1回RISC-V ソフトウェア移植及び最適化チャンピオンシップ授賞式およびRISC-V技術セミナー

PLCT Vision 2030

- RuyiSDK will serve more than 1 million RISC-V software and hardware developers in total
- An open standard system with full coverage and mass production from data centers to PCs and smartphones will be reconstructed based on RISC-V.
- RISC-V will enter the HPC TOP10

どうもありがとうございます！
質問は大歓迎です。
Thank you! Questions?

BACKUPS

Beyond RuyiSDK

The Next "Big Project"

≥ 100 chip & OS companies | ≥ 200 app comanies | ≥18 field | ≤5 years

RISC-V is the future. We're seeing it.

Three Basic Observations (Axioms)

1. Moore's Law has physical limits, but there is no limit to the **demand** for computing power.
2. The **complexity** of a software system grows superlinearly.
3. The number of **developers** capable of managing the complexity of software development is limited.

RISC-V is the future. We're seeing it.

A few conclusions deduced from three basic observations

- Domain Specific Architecture (DSA) will be everywhere.
  - There will inevitably be many (free and open) instruction sets.
- Open source software eats everything.
  - Only a few open source communities can survive in every field.
  - Only a few instruction sets will be maintained by the open source community for a long time with high quality.

RISC-V is the future. We're seeing it.

Open Software/Standards Work!

Field	*Standard*	*Free, Open Impl.*	*Proprietary Impl.*
Networking	Ethernet, TCP/IP	Many	Many
OS	Posix	Linux, FreeBSD	M/S Windows
Compilers	C	gcc, LLVM	Intel icc, ARMcc
Databases	SQL	MySQL, PostgresSQL	Oracle 12C, M/S DB2
Graphics	OpenGL	Mesa3D	M/S DirectX
ISA	??????	----------	x86, ARM, IBM360

RISC-V

- Why not successful free & open standards and free & open implementations, like other fields
- Dominant proprietary ISAs are not great designs

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"Instruction Sets Want to be Free" Krste Asanovic, Professor of UCB

RISC-V is the future. We're seeing it.

RISC-V CPU core market grows 114.9% CAGR, capturing >14% of all CPU cores by 2025

Source: Semico Research Corp, March 2021

RISC-V Penetration Rate by 2025

"The rise of RISC-V cannot be ignored... RISC-V will shake up the $8.6 Billion semiconductor IP market."

-- William Li, Counterpoint Research

Source: Counterpoint Research, September 2021

RISC-V®

RISC-V is the future. We're seeing it.

Once you choose RISC-V, you will immediately have all the software tools you need.

Mark Himelstein, https://github.com/cnrv/RVSC2022-Slides/blob/main/Mark-Himelstein-Keynote.pdf

RISC-V is the future. We're seeing it.

Open source software in several mature commercial areas already supports RISC-V.

Mark Himelstein, https://github.com/cnrv/RVSC2022-Slides/blob/main/Mark-Himelstein-Keynote.pdf

RISC-V is the future. We're seeing it.

Android 12 running on RISC-V with optimised AI performance

https://chipsalliance.org/announcement/2022/04/21/alibaba-cloud-announced-progress-in-porting-an
https://www.techradar.com/news/alibaba-cloud-is-close-to-getting-android-working-on-risc-v-silicon

Thursday, May 5th, 2022 | **Spring 2022 RISC-V Week**

Progress in Q1 2023

Emulator with graphics support and ART Java interpreter mode!

Supporting Android and ecosystem adoption of new key RISC-V specifications

- Vector extensions in QEMU, LLVM, and throughout libraries
- Continuing to pick up or extend use of Zbb (bit manipulation) optimizations

Nerds Talking to Nerds About RISC-V (Day-1) →
https://www.bilibili.com/video/BV1z84y1T7Vi/

RISC-V is the future. We're seeing it.

OpenJDK19 will natively support RISC-V

RISC-V compiler support merged on March 24th, 2022

https://github.com/openjdk/jdk/commit/5905b02c0e2643ae8d097562f181953f6c88fc89

17u/11u/8u backport staging repos are ready:
- https://github.com/openjdk/riscv-port-jdk17u
- https://github.com/openjdk/riscv-port-jdk11u
- https://github.com/openjdk/riscv-port-jdk8u

Seeded with jdk{17, 11, 8}u-dev repos respectively.

RISC-V is the future. We're seeing it.

Web Browsers (Chromium and Firefox), Mail Clients, Eclipse, LibreOffice, MultiMedia Player, etc.

RuyiSDK architecture and components

GCC support for RUYISDK

Porting RISC-V extensions on multi-version of GCC, tracking the latest feature and changes for every extension, adapting different Linux OS.

Extension supports: Bitmanip(1.0), Scalar crypto(1.0), Packed SIMD(0.96), Vector(0.7.1 & 1.0) Zfinx(1.0), Zicbo(1.0), Zmmul(1.0), Zc*(1.0), Zfh(1.0), Zfbf(0.1), Profiles(0.9)

GCC repo: https://github.com/ruyisdk/riscv-gcc
Binutils repo: https://github.com/ruyisdk/riscv-binutils

Developers:

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RuyiSDK architecture and components

Ruyisdk llvm-project

- Upstream https://github.com/llvm/llvm-project
  - RISCV Target
    - Standard extension support for Z*inx, Zc*, Zmmul, scalar cryptography, Zihintpause, Zbpbo
    - Backend Optimization
  - Middle-end Optimization, InstCombine,SCCP,LoopIdiom,LVI
  - Flang
  - LLDB, lldb-server, RV{32,64}I, A M, C, RV32F ,RV64F, D extensions
- CI monitors llvm-project for RISCV regressions every two hours https://lnt.rvperf.org/

- Downstream https://github.com/ruyisdk/llvm-project
- RVV0.7.1
- Backend Optimization

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RUYI QEMU

- Works
  - Port support for Xuantie CPUs
    - Support for RVV 0.7.1 and P extensions
    - Support for Xuantie specific vector instructions
    - Support BF16 format for float point related intructions
  - Initial support for Lichee Pi RV and Lichee Pi 4A machines

T-HEAD

- Links: https://github.com/plctlab/plct-qemu/tree/ruyi-qemu

- Main Contributor: Weiwei Li <liweiwei@iscas.ac.cn>

Questions?