



# AOSP 支持 RISC-V 移植工作进展报告

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2022 年 8 月

# 目录

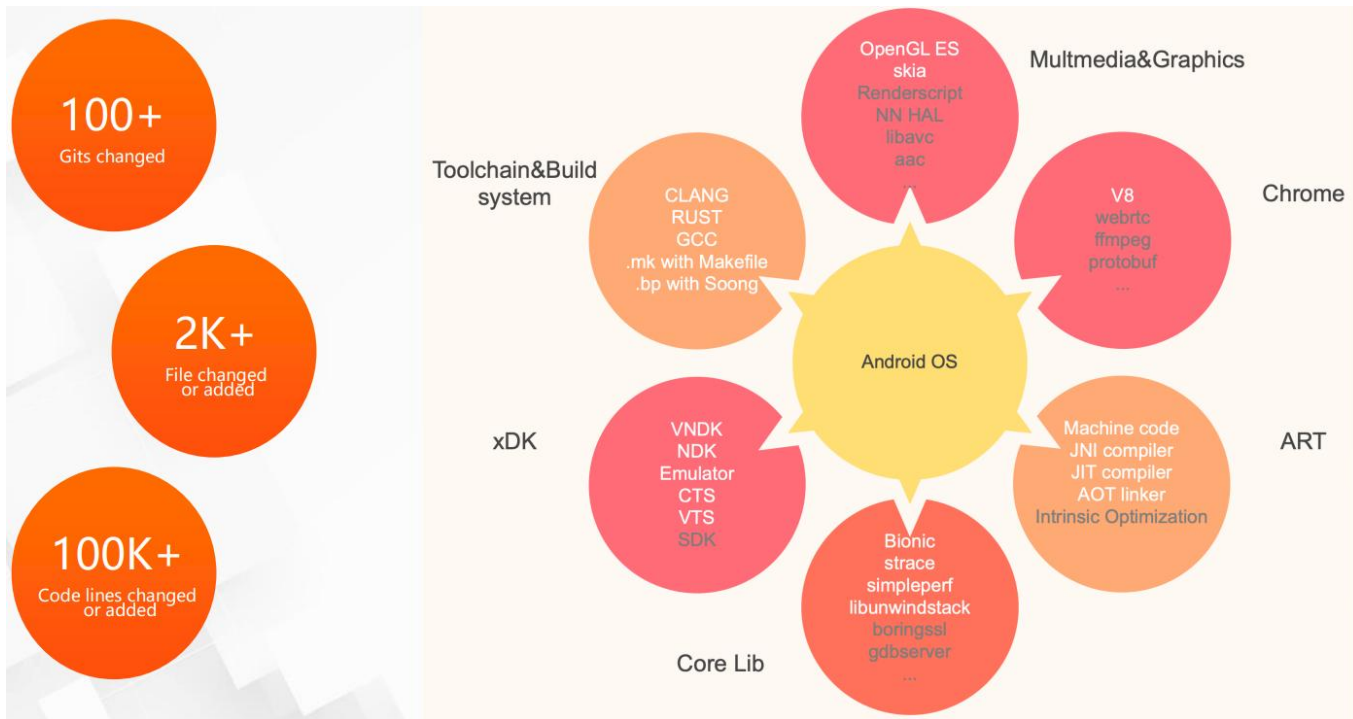
- RVI Android SIG 发展历史一览
- 从 AOSP 10 到 AOAP 12
- 路线图 Roadmap
- PLCT-lab 对 AOSP for RISC-V 的贡献
- 欢迎参与 AOSP for RISC-V
- Q&A

# RVI Android SIG 发展历史一览

- **2021 年 1 月**，阿里巴巴旗下的平头哥半导体 (T-Head) 成功将 AOSP 10 移植到自己的 RISC-V 芯片上，并开源部分代码，开源仓库地址在：<https://github.com/T-head-Semi/aosp-riscv>。
- **2021 年 5 月 20 日**，RVI Android SIG 成立 - Han Mao (Alibaba), Zheng Zhang (Imagination) 担任 chairs . <https://lists.riscv.org/g/sig-android/message/1>。  
SIG Mail list: [sig-android@lists.riscv.org](mailto:sig-android@lists.riscv.org)  
SIG Subscription: [lists.riscv.org/g/sig-android](https://lists.riscv.org/g/sig-android)
- **2021 年 10 月 20 日**，RVI Android SIG 的官方源码仓库建立：<https://github.com/riscv-android-src>，并发布 AOSP 10 的开发分支 riscv64-android-10.0.0\_dev。
- **2021 年 11 月 03 日**，RVI 仓库发布 rust toolchain
- **2022 年 1 月 14 日**，RVI 仓库发布 emulator 相关仓库
- **2022 年 1 月 17 日**，RVI 仓库发布针对 AOSP 12 的开发分支 riscv64-android-12.0.0\_dev，基于 android-12.0.0\_r2。<https://lists.riscv.org/g/sig-android/message/32>
- **2022 年 6 月 23 日**，RVI 仓库针对 AOSP 12 第二次重大更新，主要改动包括升级 toolchain，ART，CTS 和 multimedia 等部分。

# 从 AOSP 10 到 AOSP 12 (1)

## Android 10上的 RISC-V支持

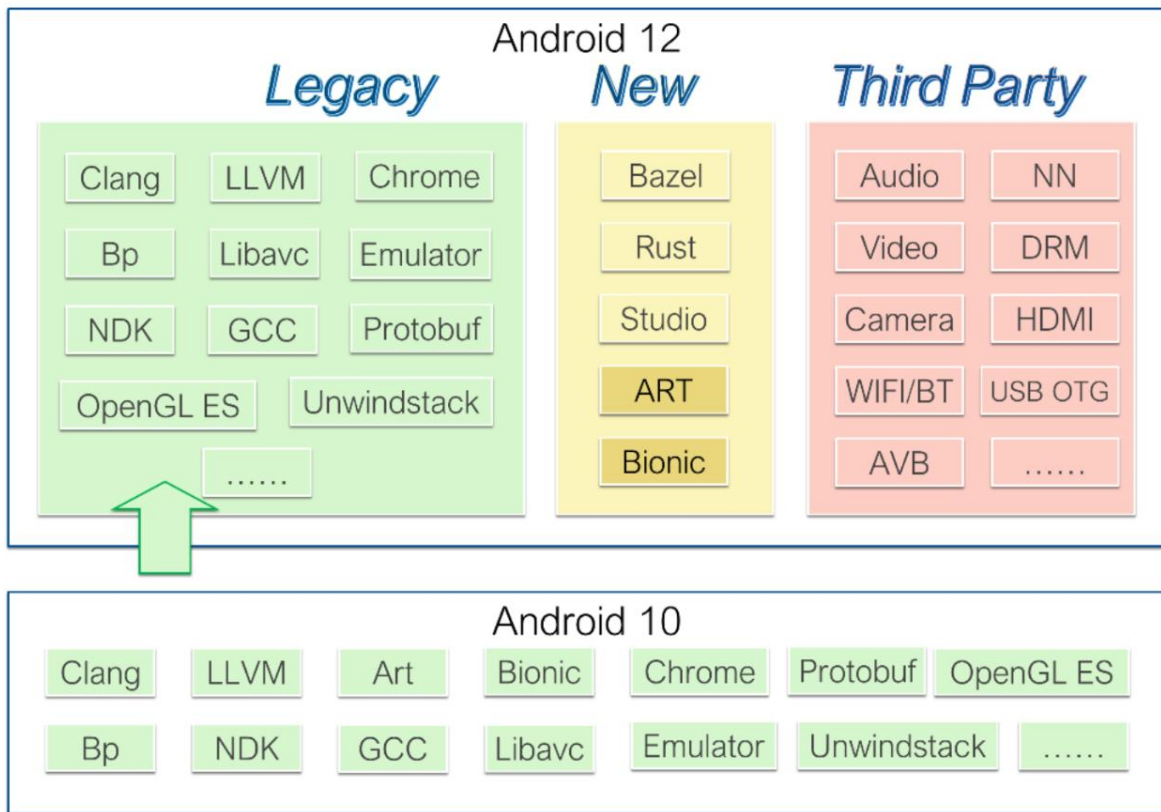


# 从 AOSP 10 到 AOSP 12 (2)

## Android 10上的 RISC-V支持

- 基于Android 10 – Release分支
- 支持平台: RVB-ICE、Emulator
- 64-bits Only
- ABI: IMAFD (整数/单双浮点/原子扩展)
- ART (JAVA运行时)
  - 支持 CXX/M 解释器, 支持 AOT、JIT加速
  - ctest & gtests: 100% 通过
  - 对指令合并、调度和intrinsic进行了优化
- Bionic (C 函数库)
  - 支持了动态链接, 系统调用, TLS和浮点相关处理
  - 测试通过率: 99%
- 调试诊断工具
  - 支持Gdbserver, Tombstone, Simpleperf 等诊断工具
  - 支持了奔溃时的堆栈回溯
  - 内核支持Ftrace函数追踪(traceview, atrace)
- 多媒体
  - 使用64位编译OMX相关支持
  - 使用CXX公共实现的编解码实现

# 从 AOSP 10 到 AOSP 12 (3)



RISC-V支持在Android12上的升级

# 从 AOSP 10 到 AOSP 12 (4)

## Android 12上的 RISC-V支持

- 添加Bazel, RUST 等编译框架支持
- 升级了Clang, bionic, ART等模块
- 适配了安卓studio
- 支持了Tflite模型的运行
- 集成了音视频播放、蓝牙、WiFi、相机和神经网络加速等模块
- XTS测试验证



# 从 AOSP 10 到 AOSP 12 (5)

## Android 12 for RISC-V 上的 XTS 工作

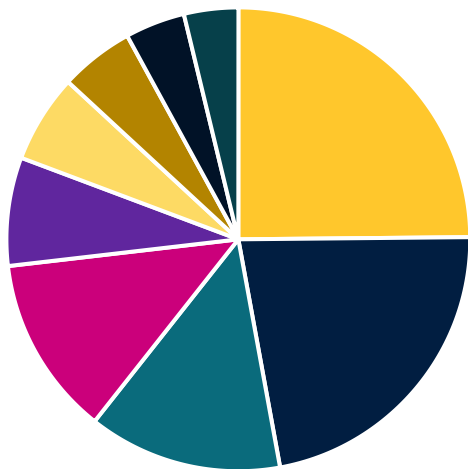
### CTS

- 1013K+ Passed/1030K+ cases
- 70% 用例集ALL PASSED

### VTs

- Tested with 108 modules
- 88% 通过率

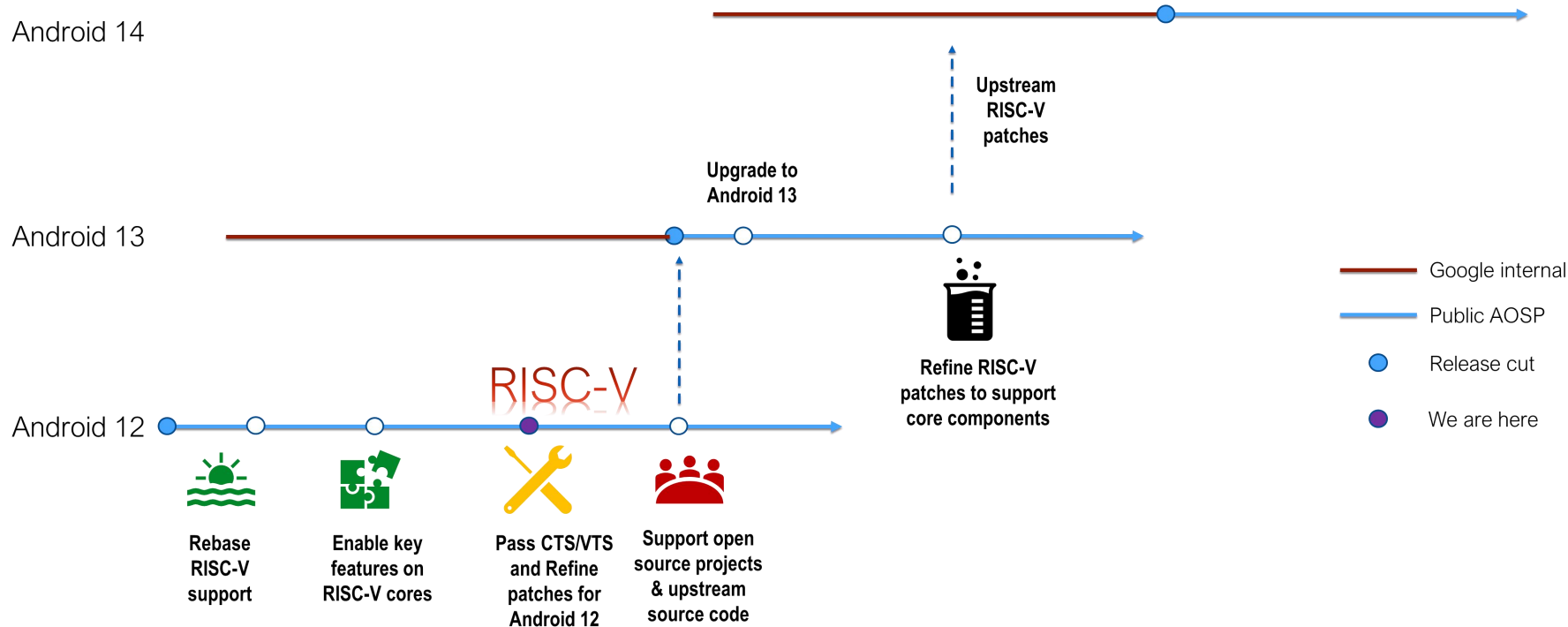
### Fails



- CtsTextTestCases
- CtsGraphicsTestCases
- CtsPrintTestCases
- CtsWindowManagerDeviceTestCases
- CtsSecurityTestCases
- CtsWebkitTestCases
- CtsAppSecurityHostTestCases



# 路线图 Roadmap



## PLCT-lab 对 AOSP for RISC-V 的贡献 (1)

- 2020 年 8 月，中科院软件所 PLCT 实验室开始基于 AOSP 10 尝试针对 RISC-V 的移植工作
- 2020 年 12 月，PLCT 实验室初步完成 bionic 的移植并在 QEMU 上启动一个最小系统  
(<https://zhuanlan.zhihu.com/p/302870095>)；建立公开的开发仓库：<https://github.com/aosp-riscv>
- 2021 年 1 月，阿里巴巴旗下的平头哥半导体 (T-Head) 成功将 AOSP 10 移植到自己的 RISC-V 芯片上，并开源部分代码，开源仓库地址在：<https://github.com/T-head-Semi/aosp-riscv>。
- 2021 年 5 月 20 日，RVI Android SIG 成立 - Han Mao (Alibaba), Zheng Zhang (Imagination) 担任 acting chairs . <https://lists.riscv.org/g/sig-android/message/1>。
- 2021 年 10 月 20 日，RVI Android SIG 的官方源码仓库建立：<https://github.com/riscv-android-src>，并发布 AOSP 10 的开发分支 riscv64-android-10.0.0\_dev。
- 2021 年 10 月，中科院软件所 PLCT 实验室宣布加入 RVI Android SIG，并贡献了我们的第一个 PR：  
[https://github.com/riscv-android-src/toolchain-llvm\\_android/pull/1](https://github.com/riscv-android-src/toolchain-llvm_android/pull/1)
- .....

## PLCT-lab 对 AOSP for RISC-V 的贡献 (2)

- LLVM (clang/rust)
- Bionic
- Build (make/soong)
- Emulator
- NDK
- Kernel
- .....
- 技术文章分享

# PLCT-lab 对 AOSP for RISC-V 的贡献 (3)

## LLVM (clang/rust)

- 提交 LLVM 上游
  - 修复了 riscv android 工具链上的 LTO 问题和 frame layout 问题: D121183, D95227, D97111
  - 在 compiler-rt 上支持浮点 round mode 的设置, D128240
  - 使 clang driver 支持传递 -mno-relax 参数到 gnu as: D120639
- GitHub: riscv-android-src
  - Build RISC-V target in LLVM for rust: toolchain-android\_rust/pull/1
  - add -mno-relax when building libc++: toolchain-llvm\_android/pull/3
  - Fix build error: toolchain-llvm\_android/pull/1
  - Backport commits to support fe\_getround and fe\_raise\_inexact in builtins: toolchain-llvm-project/pull/6

# PLCT-lab 对 AOSP for RISC-V 的贡献 (4)

## Bionic

- 针对 bionic 的 unit test 进行优化并修复了大量 failed cases, 涉及 libc (TLS/setjmp/memcpy/vfork/...), libm(fenv/round/...), linker 等。  
pass rate:
  - dynamic: 99.6% (11/3128)
  - static: 99.6% (11/2953)
- 针对 benchmark 测试中的问题, 对 linker 等模块优化代码结构。
- 清理从 aosp 10 部分移植过来不适合 aosp 12 的部分

```
emulator_riscv64:/data/nativetest64/bionic-unit-tests # ./bionic-unit-tests
-----
RUN      OK      assert_DeathTest.assert_false
RUN      OK      assert_DeathTest.assert_false (1648 ms)
RUN      OK      error_DeathTest.error_exit
RUN      OK      error_DeathTest.error_exit (1537 ms)
RUN      OK      error_DeathTest.error_exit_with_errno
RUN      OK      error_DeathTest.error_exit_with_errno (1849 ms)
RUN      OK      error_DeathTest.error_at_line_exit
RUN      OK      error_DeathTest.error_at_line_exit (2189 ms)
RUN      OK      error_DeathTest.error_at_line_exit_with_errno
RUN      OK      error_DeathTest.error_at_line_exit_with_errno (1974 ms)
RUN      OK      fdsan_DeathTest.unowned_improperly_tagged_close
RUN      OK      fdsan_DeathTest.unowned_improperly_tagged_close (993 ms)
RUN      OK      fdsan_DeathTest.unowned_incorrect_exchange
RUN      OK      fdsan_DeathTest.unowned_incorrect_exchange (1150 ms)
RUN      OK      fdsan_DeathTest.owned_untagged_close
RUN      OK      fdsan_DeathTest.owned_untagged_close (1168 ms)
RUN      OK      fdsan_DeathTest.owned_improperly_tagged_close
RUN      OK      fdsan_DeathTest.owned_improperly_tagged_close (1667 ms)
RUN      OK      fdsan_DeathTest.owned_incorrect_exchange
RUN      OK      fdsan_DeathTest.owned_incorrect_exchange (1367 ms)
RUN      OK      fdsan_DeathTest.fopen
RUN      OK      fdsan_DeathTest.fopen (928 ms)
RUN      OK      fdsan_DeathTest.closedir

emulator_riscv64:/data/benchmarktest64/bionic-benchmarks # ./bionic-benchmarks
1970-01-01T10:03:55+08:00
Running ./bionic-benchmarks
Run on (1 X 3573.69 MHz CPU )
-----
Benchmark                                     Time          CPU    Iterations
-----
BM_atomic_acquire_fence                     30.3 ns        26.4 ns    38462743
BM_atomic_empty                             14.8 ns        13.0 ns    77292638
BM_atomic_fetch_add_cs                       717 ns         661 ns    1060535
BM_atomic_fetch_add_relaxed                 36.6 ns       31.8 ns    21594208
BM_atomic_fetch_add_seq_cst                 38.3 ns       33.3 ns    20153025
BM_atomic_load_acquire                      19.8 ns       17.3 ns    38078163
BM_atomic_load_relaxed                      12.2 ns       10.9 ns    59591306
BM_atomic_seq_cst_fence                     20.9 ns       18.3 ns    41800503
BM_atomic_store_release                     20.4 ns       18.1 ns    38902483
BM_atomic_store_seq_cst                     20.7 ns       18.5 ns    37575076
BM_ctype_isalnum_n                          17.1 ns       15.1 ns    46885434
BM_ctype_isalnum_y1                         17.0 ns       15.1 ns    45440530
BM_ctype_isalnum_y2                         16.4 ns       14.9 ns    44186452
BM_ctype_isalnum_y3                         16.5 ns       14.6 ns    46903719
BM_ctype_isalpha_n                          2.62 ns        2.33 ns    325201892
BM_ctype_isalpha_y1                         3.36 ns        3.12 ns    173782825

emulator_riscv64:/data/benchmarktest64/linker-reloc-bench # ./linker-reloc-bench
1970-01-01T11:56:52+08:00
Running ./linker-reloc-bench
Run on (1 X 2502.14 MHz CPU )
-----
Benchmark                                     Time          CPU    Iterations
-----
BM_linker_relocation/real_time             11827001 us    3998 us        1
```

# PLCT-lab 对 AOSP for RISC-V 的贡献 (5)

## Build (make/soong)

- 清理从 aosp 10 部分移植过来不适合 aosp 12 的部分
- clang 启用 integrated as
- clang 添加 -mno-relax 选项

```
commit b08a967d3007a69afb20ebd6c318adb58737a34f (HEAD, riscv-and  
Author: Wang Chen <wangchen20@iscas.ac.cn>  
Date:   Mon Jul 11 09:39:45 2022 +0800
```

```
    remove build options for aosp 10
```

```
commit 5f86d0f6057cb89cef19a843841112b2706e5a51  
Author: Chen Wang <wangchen20@iscas.ac.cn>  
Date:   Fri Jun 10 09:33:06 2022 +0800
```

```
    add no-relax
```

```
Upstreaming LLD doesn't support linker relaxation for RISC-V. When the  
linker find relocations that used by linker relaxation, it will report  
error and suggest us to compile with -mno-relax
```

```
commit ab856e09a9a2603fb630036ec079841a313259ba  
Author: Chen Wang <wangchen20@iscas.ac.cn>  
Date:   Wed Jun 8 15:35:22 2022 +0800
```

```
    use clang integrated as
```

```
commit 981beffd910986cd7701227d0b4f698a59e795e7  
Author: Chen Wang <wangchen20@iscas.ac.cn>  
Date:   Wed Feb 23 13:29:24 2022 +0800
```

```
    restore some minor changes.
```

```
Signed-off-by: Chen Wang <wangchen20@iscas.ac.cn>
```

# PLCT-lab 对 AOSP for RISC-V 的贡献 (6)

## Emulator

- 针对 emulator 的构建系统进行优化，补充自动化生成 cmake 脚本。
- 清理代码，以及优化。

```
commit 53c3712ada2969665f7fbb9fbb87d850ffccce7
Author: Wang Chen <wangchen20@iscas.ac.cn>
Date: Sun Apr 24 09:18:56 2022 +0800

commit 4edcafddee04c66ade54c18a061eecd9e484aacd
Author: Chen Wang <wangchen20@iscas.ac.cn>
Date: Thu Apr 14 17:27:03 2022 +0800

commit 290c536349afc99a8773b9965a81e12d7355e36d
Author: Chen Wang <wangchen20@iscas.ac.cn>
Date: Wed Apr 13 13:30:31 2022 +0800

commit c49cae428be2f9941bd038f0b4373b6f342552e4
Author: Chen Wang <wangchen20@iscas.ac.cn>
Date: Wed Apr 13 13:16:48 2022 +0800

commit 38badb7684ac9dd784add485eccc822818c92d3f
Author: Chen Wang <wangchen20@iscas.ac.cn>
Date: Wed Apr 13 13:24:37 2022 +0800

complete dependencies for emulator

- OPTION_MINBUILD is build all 64 bits binaries.
- default options should depend on all binaries.
```

# PLCT-lab 对 AOSP for RISC-V 的贡献 (7)

## NDK

- 整理 riscv-android-src/platform-prebuilts-ndk, 清除旧的文件

## Kernel

- 为模拟器内核添加缺省构建配置
- 更新模拟器内核

.....

```
commit f796249806272e4cc7a65082094cf2afde93bc31 (grafted, HEAD, riscv-and
Author: Wang Chen <wangchen20@iscas.ac.cn>
Date:   Fri Apr 29 13:21:52 2022 +0800
```

```
redo this repo for 12
```

```
Please read
```

```
https://github.com/riscv-android-src/platform-prebuilts-ndk/issues/1
for why I think this redo is needed.
```

```
commit d575d4eafa08809eccda08aeb790d9bf2b4fa0 (HEAD -> riscv-android12-5.10-lts,
Author: Wang Chen <wangchen20@iscas.ac.cn>
Date:   Sun Apr 24 14:32:14 2022 +0800
```

```
added defconfig for ranchu
```

```
added ranchu_defconfig for emulator riscv64.
```

```
added HAVE_EFFICIENT_UNALIGNED_ACCESS to fix the load failure when
loading eBPF programs with syscall bpf(2)
```

```
commit cc5e0ae5c7afe5ddc1c644937b0b13eca9d64633 (grafted, HEAD, riscv-android/1
bAuthor: Wang Chen <wangchen20@iscas.ac.cn>
```

```
mDate:   Tue Apr 26 10:07:30 2022 +0800
```

```
m
```

```
s    updated kernel for emulator
```

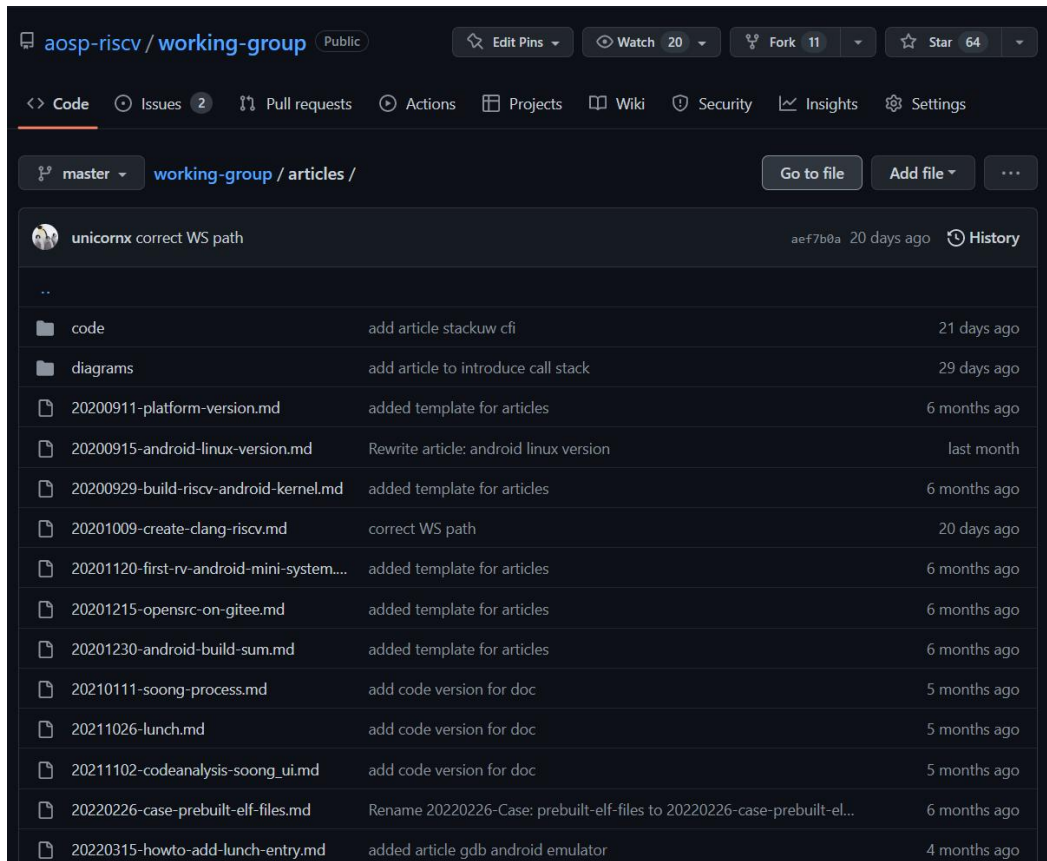
```
build with kernel-common, commit d575d4eafa08809eccda08aeb790d9bf2b4fa0
```

```
Signed-off-by: Wang Chen <wangchen20@iscas.ac.cn>
```



# PLCT-lab 对 AOSP for RISC-V 的贡献 (8)

## 技术文章分享



Repository: aosp-riscv / working-group (Public)

Navigation: Code, Issues (2), Pull requests, Actions, Projects, Wiki, Security, Insights, Settings

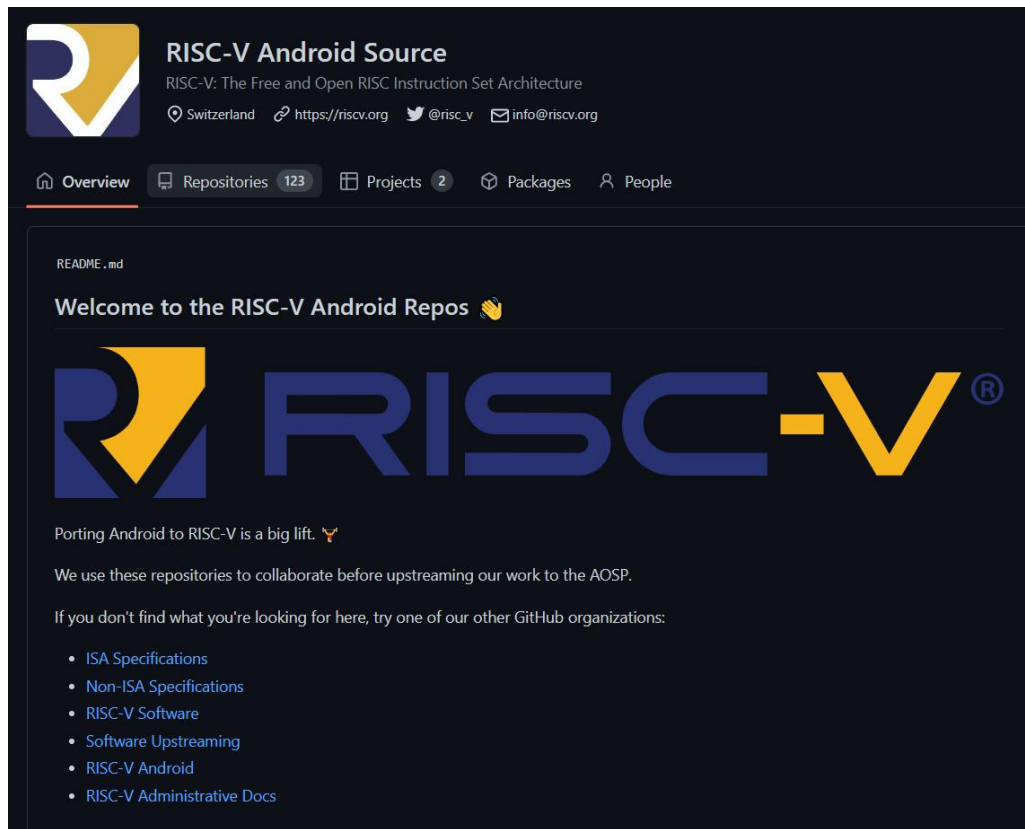
Branch: master | working-group / articles /

Buttons: Go to file, Add file, ...

File	Commit Message	Time Ago
..		
code	add article stackuw cfi	21 days ago
diagrams	add article to introduce call stack	29 days ago
20200911-platform-version.md	added template for articles	6 months ago
20200915-android-linux-version.md	Rewrite article: android linux version	last month
20200929-build-riscv-android-kernel.md	added template for articles	6 months ago
20201009-create-clang-riscv.md	correct WS path	20 days ago
20201120-first-rv-android-mini-system....	added template for articles	6 months ago
20201215-opensrc-on-gitee.md	added template for articles	6 months ago
20201230-android-build-sum.md	added template for articles	6 months ago
20210111-soong-process.md	add code version for doc	5 months ago
20211026-lunch.md	add code version for doc	5 months ago
20211102-codeanalysis-soong_ui.md	add code version for doc	5 months ago
20220226-case-prebuilt-elf-files.md	Rename 20220226-Case: prebuilt-elf-files to 20220226-case-prebuilt-el...	6 months ago
20220315-howto-add-lunch-entry.md	added article gdb android emulator	4 months ago

# 欢迎参与 AOSP for RISC-V (1)

<https://github.com/riscv-android-src>




The screenshot shows the GitHub repository page for "RISC-V Android Source". The repository is described as "RISC-V: The Free and Open RISC Instruction Set Architecture". It is located in Switzerland and has a website at <https://riscv.org>, a Twitter handle @risc\_v, and an email address info@riscv.org. The repository has 123 repositories, 2 projects, and 0 packages. The README.md file is selected, showing a welcome message and the RISC-V logo. The README text includes a welcome message, a statement about porting Android to RISC-V, and a list of other GitHub organizations to visit.

**RISC-V Android Source**  
RISC-V: The Free and Open RISC Instruction Set Architecture  
Switzerland <https://riscv.org> [@risc\\_v](#) [info@riscv.org](mailto:info@riscv.org)

Overview Repositories 123 Projects 2 Packages People

README.md

Welcome to the RISC-V Android Repos 🙌



Porting Android to RISC-V is a big lift. 🙌

We use these repositories to collaborate before upstreaming our work to the AOSP.

If you don't find what you're looking for here, try one of our other GitHub organizations:

- [ISA Specifications](#)
- [Non-ISA Specifications](#)
- [RISC-V Software](#)
- [Software Upstreaming](#)
- [RISC-V Android](#)
- [RISC-V Administrative Docs](#)

# 欢迎参与 AOSP for RISC-V (2)

<https://github.com/riscv-android-src/riscv-android/blob/main/doc/android12.md>

## Setup Android 12 on RISC-V

To download the RISC-V Android source tree to your working directory:

```
mkdir ~/riscv-android-src && cd ~/riscv-android-src
repo init -u git@github.com:riscv-android-src/manifest.git -b riscv64-android-12.0.0_dev
repo sync
cd prebuilts/rust/
git lfs pull
cd -
cd cts/
git lfs pull
cd -
rm external/angle/Android.bp
```

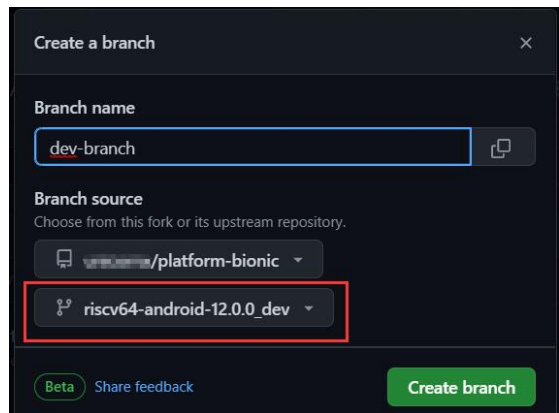
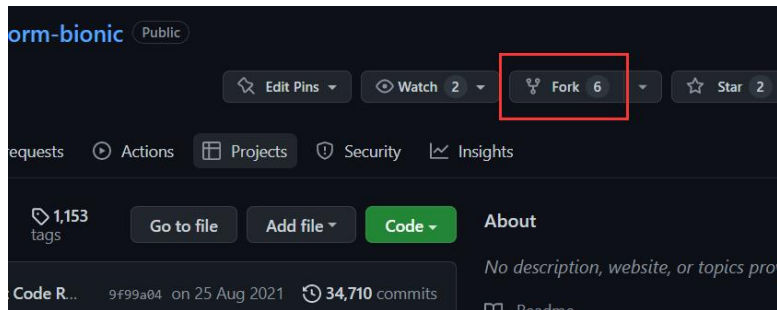
Build full emulator image with command:

```
source build/envsetup.sh
lunch sdk_phone64_riscv64
m -j
```

Run the RISC-V 64 AVD system image in the Android Emulator:

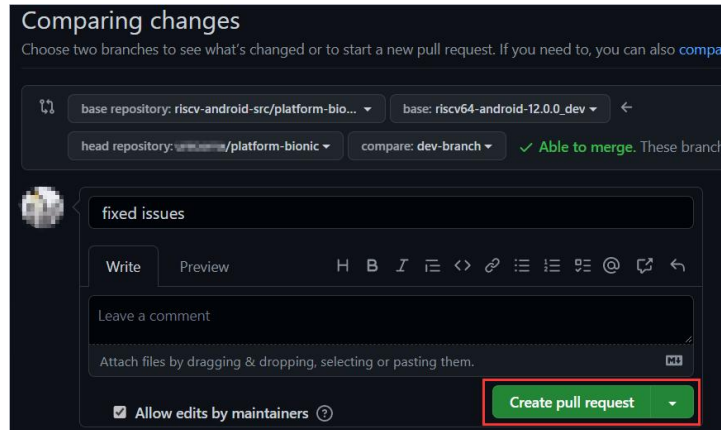
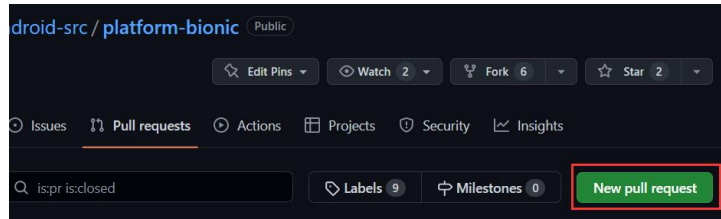
```
emulator -no-qt -show-kernel -noaudio -selinux permissive -qemu -smp 1 -m 3584M -bios kernel/prebuilts/5.10/riscv64/fw_jump.bin
```

## 欢迎参与 AOSP for RISC-V (3)



Fork the repository you want to change  
and create development branch

```
vi Android.mk
git commit Android.mk -m "Add RISC-V support in Android.mk"
git push origin HEAD:refs/for/riscv64-android-12.0.0_text
```



Commit your changes and send a pull request

## Q&A

- .....



# Thank You

