Upstream Embedded Linux on RISC-V: The Good, the Bad and the Ugly

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Speaking today

Marcel Ziswiler

ROLE

Founder ZisiSoft GmbH

Consultant Software Engineer
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TENURE

Joined Codethink
in 2024

PAST ENGAGEMENTS

Senior Linux Expert, System Engineer, Technical Project Leader
Noser Engineering

Platform Manager Embedded Linux
Toradex

EDUCATION

MS Computer Science
ETH Zurich

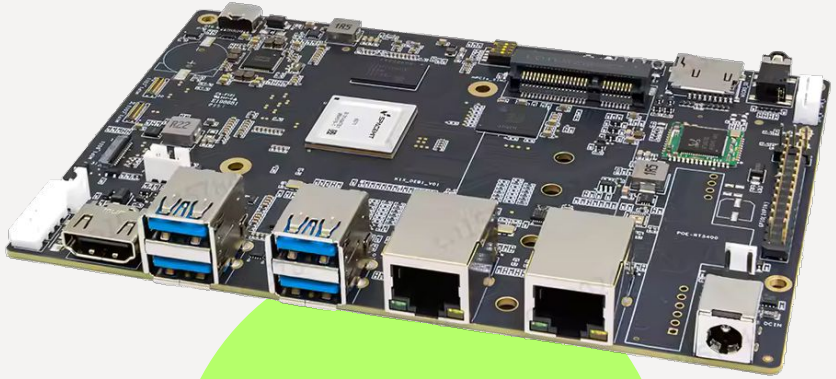
Certificate in Embedded Systems Technologies UCI

Contents

Banana Pi BPI-F3

Banana Pi BPI–F3

- Industrial grade RISC-V development board
- SpacemiT K1 8-core SoC
- 2.0 TOPs AI accelerator
- 2/4/8/16 GB DDR
- 8/16/32/128 GB eMMC
- 2x GbE Ethernet
- 4x USB 3.0
- M.2 PCIe
- HDMI
- Dual MIPI-CSI camera
- Starting at 60 bucks



Banana Pi
open source
hardware

Downstream Bianbu v2.0.4

Downstream Bianbu v2.0.4

- V2.0.4 got released on Dec 11, 2024
- Bianbu-24.04-minimal-k1-v2.0.4-release-20241205234138.img.zip
- Booting e.g. from uSD card
- Downstream sources
  - from SpacemiT on gitee
  - from Banana Pi on github
- OpenSBI 1.3
- U-Boot 2022.10
- Linux kernel 6.6.63
- Based on Ubuntu 24.04 providing Debian APT source

Featuring

Ugly Chinese vendor downstream

Toolchain

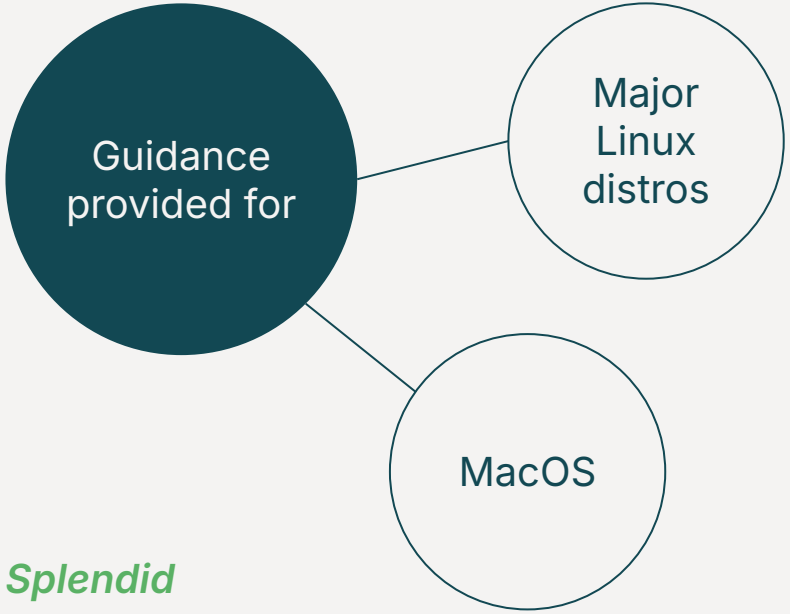
A word about RISC-V Toolchains

- RISC-V Collaboration (riscv-collab on github) provides pre-built and verified gcc and llvm x86-64 cross-toolchains

As of Jan 20, 2025:

- riscv64-glibc-ubuntu-24.04-gcc-nightly-2025.01.20-nightly.tar.xz gcc 14.2.0
- riscv64-glibc-ubuntu-24.04-llvm-nightly-2025.01.20-nightly.tar.xzllvm 19.1.7

Or build your own



Splendid

Upstream U–Boot

Upstream U–Boot

- Initial support merged Dec 18, 2024
- 1cd239f44438 ("riscv: spacemit: bananapi_f3: initial support added")
- Documents use of downstream OpenSBI but confirmed working with upstream as well

In-flight as of Jan 20, 2025:

- [PATCH v5] riscv: spacemit: k1: probe dram size during boot phase.

ToDO

So far so good.

Upstream U–Boot

```
sys: 0x0
try sd...
bm:3
j...

U-Boot SPL 2022.10spacemit-dirty (Dec 05
2024 - 14:13:45 +0000)
[   0.347] DDR type LPDDR4X
[   0.366] lpddr4_silicon_init consume 19ms
[   0.367] Change DDR data rate to 2400MT/s
[   0.513] ## Checking hash(es) for config
conf-1 ... OK
[   0.515] ## Checking hash(es) for Image
opensbi ... OK
[   0.520] ## Checking hash(es) for Image
uboot ... OK
```

```
[   0.525] ## Checking hash(es) for Image
fdt-1 ... OK
[   0.574] ## Checking hash(es) for config
config_1 ... OK
[   0.577] ## Checking hash(es) for Image
opensbi ... crc32+ OK

U-Boot 2025.01-00957-gd9c4db55d8e4 (Jan 24
2025 - 22:32:06 +0100)

DRAM:  16 GiB
Core:  18 devices, 7 uclasses, devicetree:
separate
Loading Environment from nowhere... OK
In:    serial@d4017000
Out:   serial@d4017000
Err:   serial@d4017000
Net:   No ethernet found.
=>
```

Upstream Linux Kernel

Upstream Linux Kernel

Initial support merged Jan 17, 2025
(only in -next so far, targeting 6.14)

- – bpi-f3 device tree
  – pinctrl
  – console UART

In-flight as of Jan 20, 2025:

- [PATCH v4 0/4] riscv:
  spacemit: add gpio support for K1 SoC
- [PATCH v4 0/4] Add clock controller support for SpacemiT K1
- [PATCH 0/2] Add support for the P1 PMIC from SpacemiT
- [PATCH v4 0/2] riscv:
  spacemit: add i2c support to K1 SoC

ToDO

- **PMIC patches fail to build, missing stuff**
- **i2c patches missing device tree parts, hand-tweaked for poking eeprom**
- **missing more peripheral drivers**

Not too bad.

Upstream Linux Kernel

```
=> run detect_dtb; run loadknl; run
loaddtb; run loadramdisk
=> setenv bootargs console=ttyS0,115200n8
=> booti ${kernel_addr_r} ${ramdisk_combo}
${dtb_addr}

[    0.000000] Linux version
6.13.0-next-20250124-00012-gf9f1ac6ef23a-di
rty (zim@toolbx)
(riscv64-unknown-linux-gnu-gcc () 13.2.0,
GNU ld (GNU Binutils) 2.43.1) #7 SMP Mon
Jan 27 19:12:51 CET 2025
[    0.000000] Machine model: Banana Pi
BPI-F3

[    0.043751] pinctrl core: initialized
pinctrl subsystem
```

```
[    0.043751] pinctrl core: initialized
pinctrl subsystem

[    0.390700] Serial: 8250/16550 driver, 4
ports, IRQ sharing disabled
[    0.392612] printk: legacy console
[ttyS0] disabled
[    0.392918] d4017000.serial: ttyS0 at
MMIO 0xd4017000 (irq = 13, base_baud =
928562) is a XScale
[    0.392994] printk: legacy console
[ttyS0] enabled

[    1.521225] i2c_dev: i2c /dev entries
driver

(initramfs) i2ctransfer -y 1 r8@80
0xab 0xad 0xc0 0xfe 0xff 0xff 0xff 0xff
```

FreedesktopSDK

FreedesktopSDK

- BuildStream/BuildBox as build system
  - only native compilation
  - no cross-compilation
- tried QEMU user mode emulation aka qemu-user-static
  - works but sooo slooow
  - waiting overnight for kernel compilation
- luckily Codethink owns a few beefy Milk-V Pioneer machines with 64-core SOPHON SG2042 server SoCs
- Codethink is a frequent contributor in the RISC-V space
- FreedesktopSDK on BPI-F3 is work in progress

Native RISC-V compilation

BPI-F3 Elements

- components/opensbi-spacemit-k1.bst
  - downstream OpenSBI
- components/u-boot-spacemit-k1.bst
  - downstream U-Boot
- components/linux-spacemit-k1.bst
  - downstream Linux kernel
- vm/firmware/bootloader-spacemit-k1.bst
  - genimage generated disk image of the the above
  - first 80 bytes bootinfo
- plus regular RISC-V user space e.g. vm/minimal/efi.bst
  - genimage generated disk image incl. EFI etc.

ToDO

- **do more testing**
- **iron out any remaining issues**
- **Contributors**
  - Dom Rodriguez
  - Matteo Martelli

Native RISC-V compilation.

FreedesktopSDK

```
bst -o downstream_bsp spacemit_k1 build vm/firmware/bootloader-spacemit-k1.bst
bst -o downstream_bsp spacemit_k1 artifact checkout vm/firmware/bootloader-spacemit-k1.bst
--directory bootloader-spacemit-k1

bst -o downstream_bsp spacemit_k1 build vm/minimal/efi.bst
bst -o downstream_bsp spacemit_k1 artifact checkout vm/minimal/efi.bst --directory efi

[root@b19e954c978d freedesktop-sdk]# ls -l bootloader-spacemit-k1/nor
total 2024
-rw-r--r-- 1 root root   16384 Jan 30 17:01 env.bin
drwxr-xr-x 2 root root    4096 Jan 30 17:01 factory
-rw-r--r-- 1 root root  136583 Jan 30 17:01 fw_dynamic.itb
-rw-r--r-- 1 root root     633 Jan 30 17:01 partition_2M.json
-rw-r--r-- 1 root root 1907714 Jan 30 17:01 u-boot.itb
[root@b19e954c978d freedesktop-sdk]# ls -l bootloader-spacemit-k1/sd
total 4116
-rw-r--r-- 1 root root 4214784 Jan 30 17:01 disk.img
[root@b19e954c978d freedesktop-sdk]# ls -l efi
total 910360
-rw-r--r-- 1 root root 932204544 Jan 30 17:45 disk.img
```

Yocto Project

Yocto Project

- meta-riscv on github
- general hardware specific BSP overlay for RISC-V based devices
- inquiry on bpi-f3 support on Jul 3, 2024 in issue #480
- but no progress ever since

ToDO

- **Well, everything**

Ugly or not, just means work...

BPI-F3 Recipes

- conf/machine/bananapi-bpi-f3.conf
- recipes-bsp/u-boot/u-boot-spacemit_v2022.10.bb
  – downstream U-Boot
- recipes-kernel/linux/linux-bananapi-bpi-f3-dev.bb
  – disable failing stuff
- wic/bananapi-bpi-f3.wks
  – disk image of the the above
  – first 80 bytes bootinfo

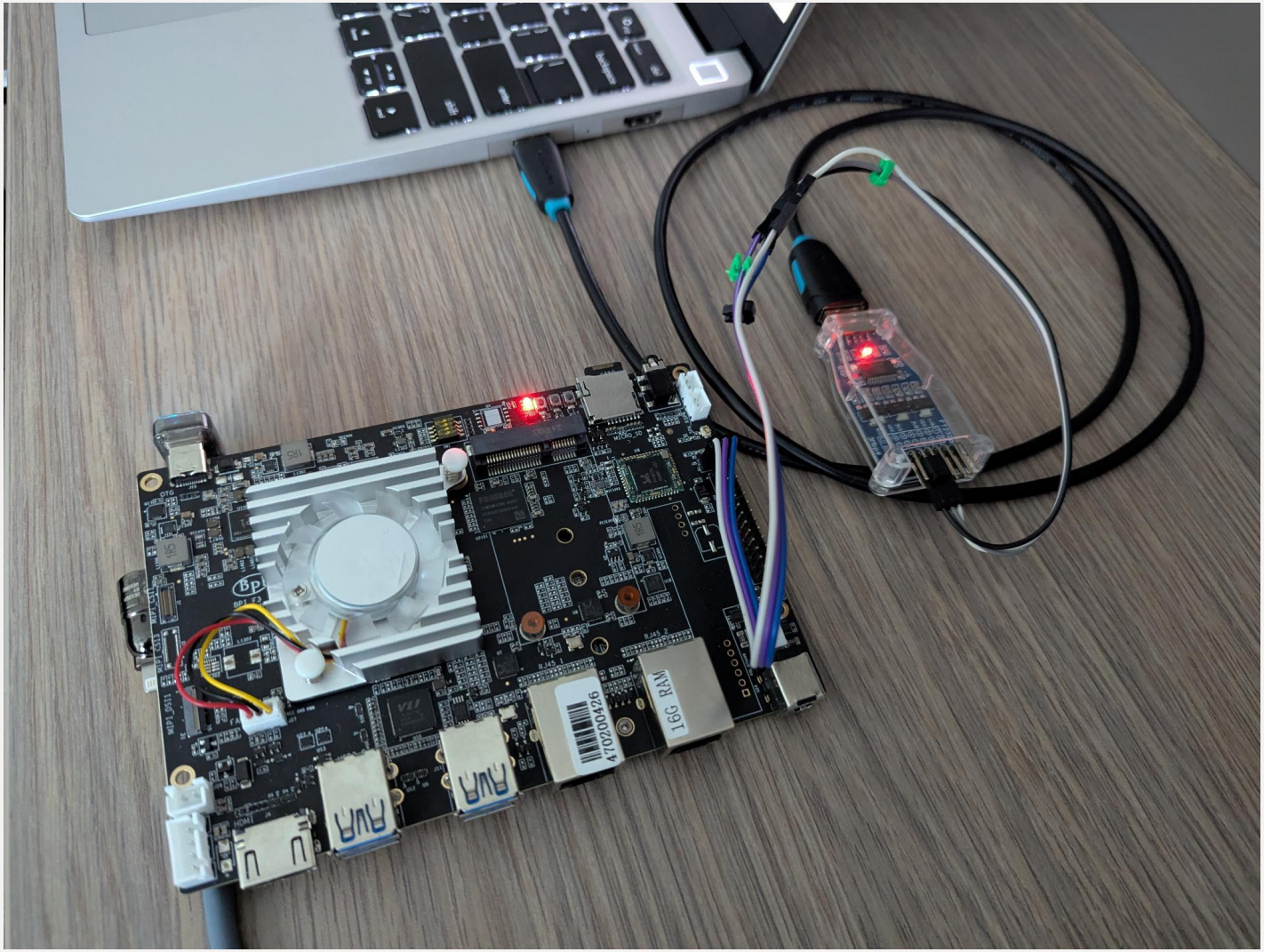
ToDO

- **Do more testing**
- **Iron out any remaining issues**

When the beauty emerges.

Live Demo

Live Demo



References

References

Banana Pi BPI-F3
https://docs.banana-pi.org/en/BPI-F3/BananaPi_BPI-F3
https://wiki.banana-pi.org/Banana_Pi_BPI-F3

Toolchain
https://github.com/riscv-collab/riscv-gnu-toolchain

SpacemiT official Bianbu image release link
http://archive.spacemit.com/image/k1/version/bianbu

Bianbu Linux BSP
https://bianbu-linux.spacemit.com/en

Bianbu Desktop 2.0 Release Notes
https://bianbu.spacemit.com/en/release_notes/bianbu_desktop_2.0

References

- [PATCH v5] riscv: spacemit: k1: probe dram size during boot phase
  https://lore.kernel.org/all/20250120-get-dram-size-v5-1-2ad4f2e7a270@per1cycle.org
- [PATCH v4 0/4] riscv: spacemit: add gpio support for K1 SoC
  https://lore.kernel.org/all/20250121-03-k1-gpio-v4-0-4641c95c0194@gentoo.org
- [PATCH v4 0/4] Add clock controller support for SpacemiT K1
  https://lore.kernel.org/all/20250103215636.19967-2-heylenay@4d2.org
- [PATCH 0/2] Add support for the P1 PMIC from SpacemiT
  https://lore.kernel.org/all/20241230-k1-p1-v1-0-aa4e02b9f993@gmail.com
- [PATCH v4 0/2] riscv: spacemit: add i2c support to K1 SoC
  https://lore.kernel.org/all/20241125-k1-i2c-master-v4-0-0f3d5886336b@gmail.com
- FreedesktopSDK BPI-F3 Merge Request
  https://gitlab.com/freedesktop-sdk/freedesktop-sdk/-/merge_requests/24432
- Yocto Project BPI-F3 WIP
  https://github.com/ziswiler/meta-riscv/tree/add-bpi-f3-support

Thank You.

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