No Line Like Mainline

Update On The Fully Mainline Software Stack For Rockchip SoCs

FOSDEM'26

COLLABORA

:~$ whoami

- Nicolas Frattaroli <nicolas.frattaroli@collabora.com>
- From Switzerland
- Linux kernel contributor since 2021
  - First contribution: upstreaming the Rockchip I2S/TDM driver
- Started to work as a Software Engineer at Collabora in January 2025
  - Several contributions to mainline Rockchip since then
    - `$ git log --oneline --author="Nicolas Frattaroli" --since=2025-01-01 --grep='rockchip' -i | wc -l`
      `71`
  - However, talk is about community contributions as a whole, not just Collabora

Why Rockchip?

- Affordable & widely available development boards
- Reasonable performance, great multimedia capabilities
  - First vendor to have hardware decoding for obscure H.264 10-bit profile, years before interest grew due to HDR and HEVC licensing mess
- Technical Reference Manuals readily available, with full memory map
  - Sometimes even from Rockchip themselves publicly :)
- Company participates in upstream development
  - Means many engineers are familiar with upstream processes and code style

A Brief Introduction To Rockchip Naming

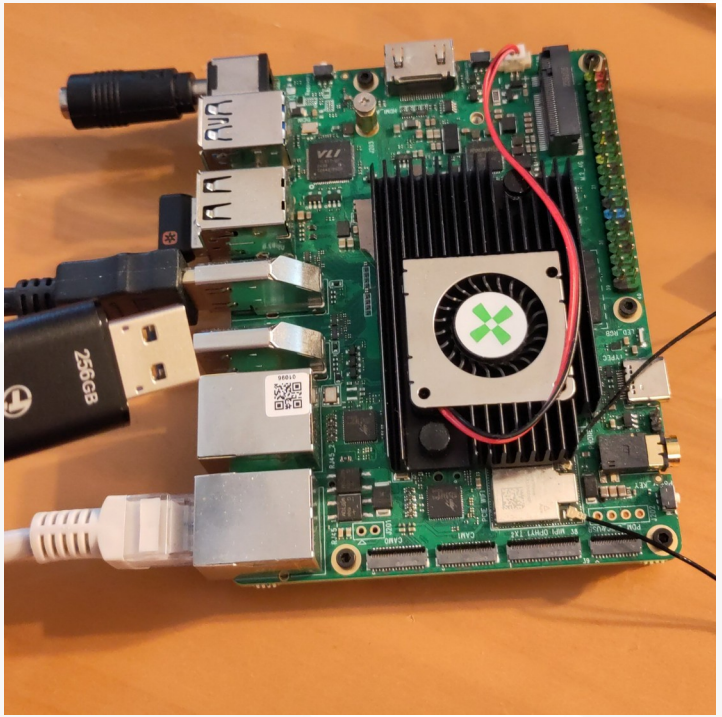
- General naming scheme: **RK3<*X*><*YY*>**
  - There are others, we will not talk about the others today
  - **X:** "Generation", so far: 0, 1, 2, 3, 5.
    - Why no 4? Educated guess: Chinese numerology
    - "Generation" is marketing, hardware designs sometimes get substantially reworked between SoCs within the same "generation"
  - **YY:** Performance class within that generation, higher = more powerful
    - Lots of digit "8", educated guess again: Chinese numerology
  - Sometimes followed by a letter to denote some variant
    - e.g. "J" for industrial, "S" for low power, etc.

Some Examples

- RK3588: Current flagship, 4P+4E (Cortex-A76 + Cortex-A55), Mali-G610, 4-channel LPDDR5
  - About 2022 entry-level Intel Chromebook performance, good I/O for SBCs
- RK3588S: Cut-down version of flagship, missing PCIe3x4, HDMI input, and CAN
- RK3576: Sub-flagship, older licensed IP (A72/A53, Bifrost GPU), but newer in-house IP
- RK3399: Previous generation flagship
- PX30: I thought we agreed we wouldn't talk about the others
- RV1126B: Come on I only have so many slides

The Big Picture

Let's try to use an RK3588 like a PC

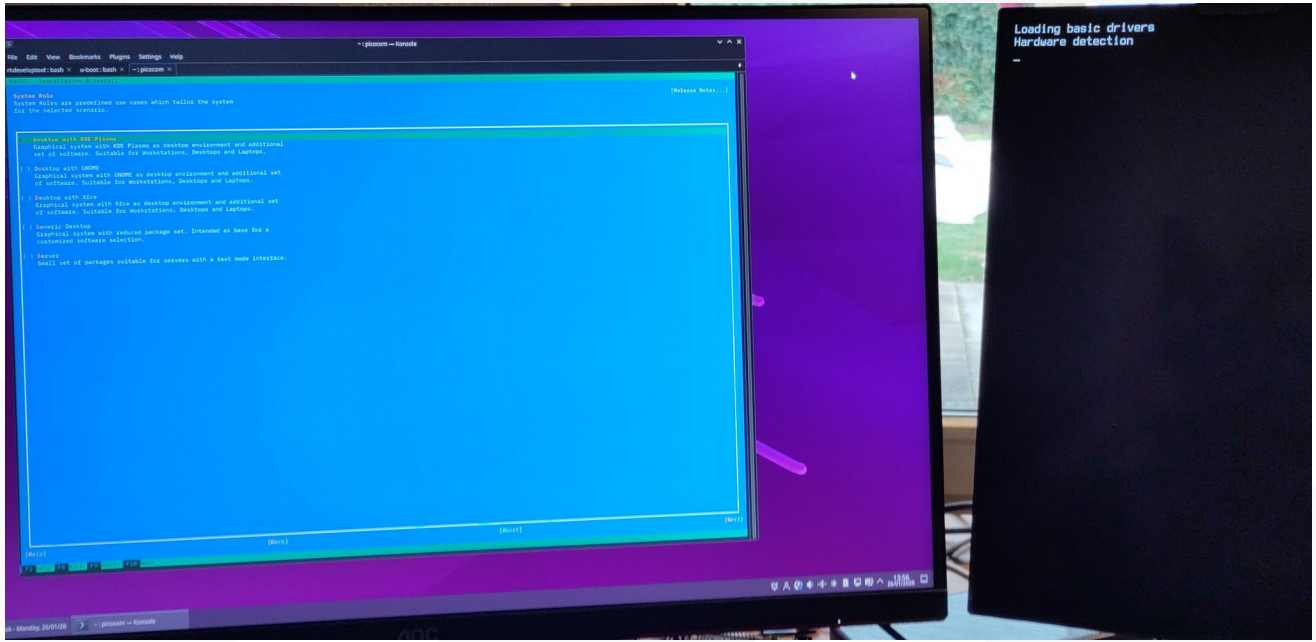


Radxa ROCK 5T with U-Boot v2026.01 on SPI flash and an empty NVMe drive installed below.

Generic aarch64 distro installer on USB3 thumb drive.

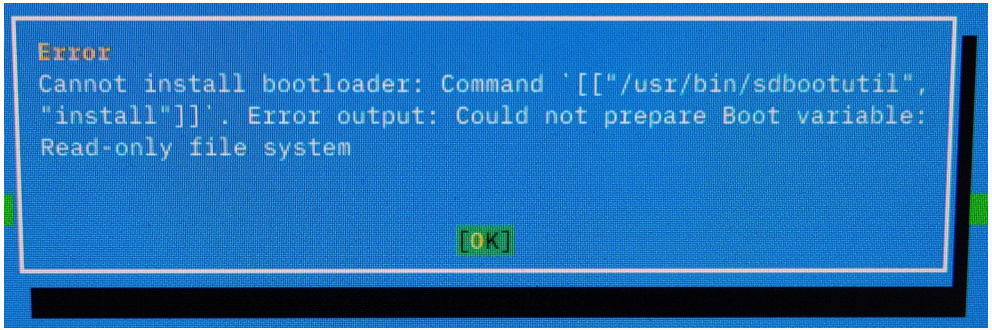
HDMI monitor, keyboard, network.

Trying openSUSE Tumbleweed

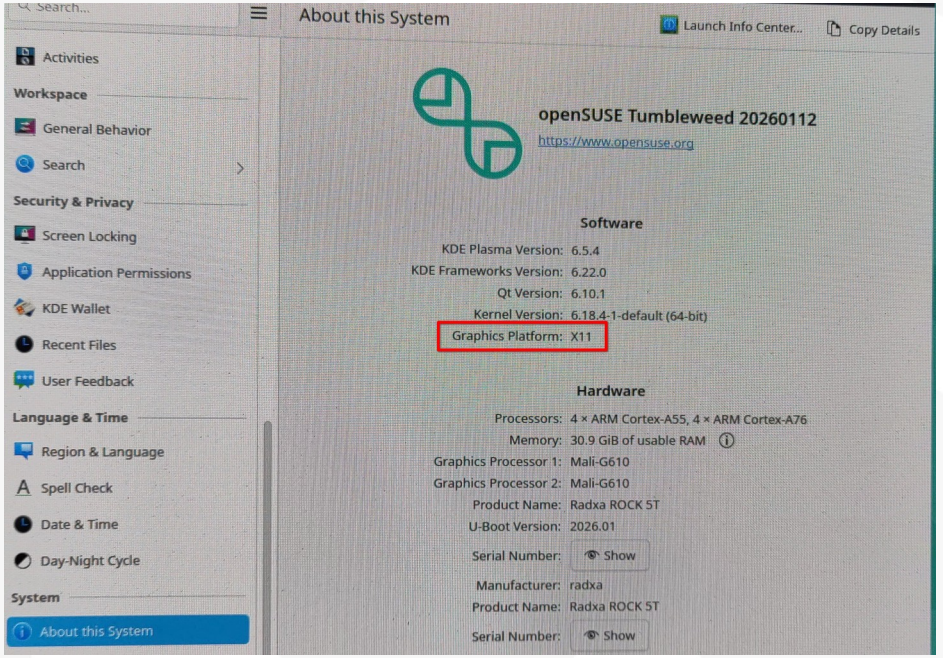


Boots into a Linux kernel that clearly can display video output (right monitor), but then only shows a text installer on serial (left)

Installs Fine Though

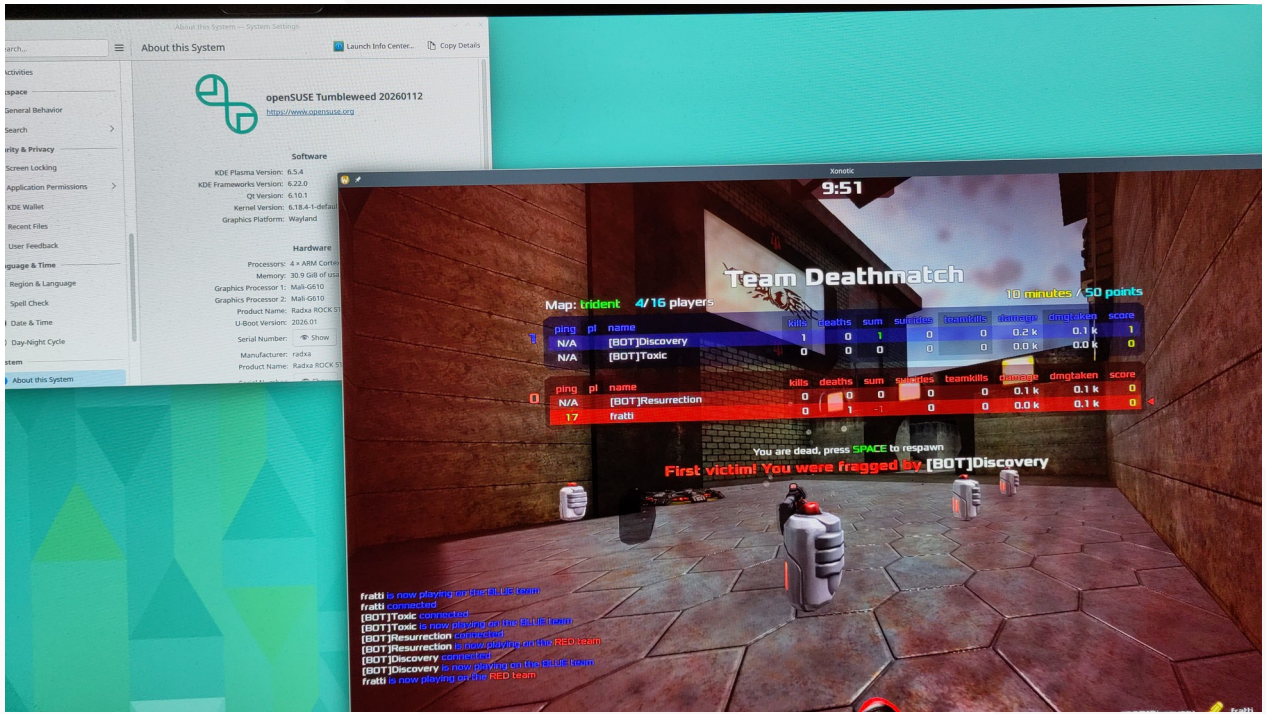


Non-fatal sdboot error, installation completes after ignoring it however and system boots fine from NVMe



... into the terrible unaccelerated X11 session

Finally



Once in Wayland, we can enjoy our high-octane gaming

Conclusion Of This Experiment

- Distro installers are horrendous garbage, though openSUSE TW limped to the finish line
  - Video output in U-Boot for RK3588 would be nice to make this smoother though
- If you work on a distribution, pick up any mainline supported board with a mainline supported SoC and try your UEFI installer on mainline U-Boot
  - Even if your ARM SystemReady IoT version works, if your desktop edition's installer falls over, users will assume there's a deeper issue than just installers sucking
- Beyond the installer snags, mainline U-Boot + Linux Just Works™ for a Desktop-like experience. No need for device specific images
- If you're deploying these boards in an embedded IoT context, installers don't matter anyway, so your generic ARM SystemReady UEFI images should work with no issues

Mali GPUs and Open Drivers

- RK3588 uses a licensed Arm Mali-G610 GPU design
  - SoC serves as widely available development platform for Mali Valhall CSF GPUs
- Allowed us to write a new kernel driver (Panthor) that userspace Mesa targets
- Userspace drivers (panfrost/panvk) in upstream Mesa
- PanVK officially passed Vulkan 1.4 conformance on RK3588 this year
  - Panfrost also officially passes OpenGL ES 3.1 conformance on RK3588

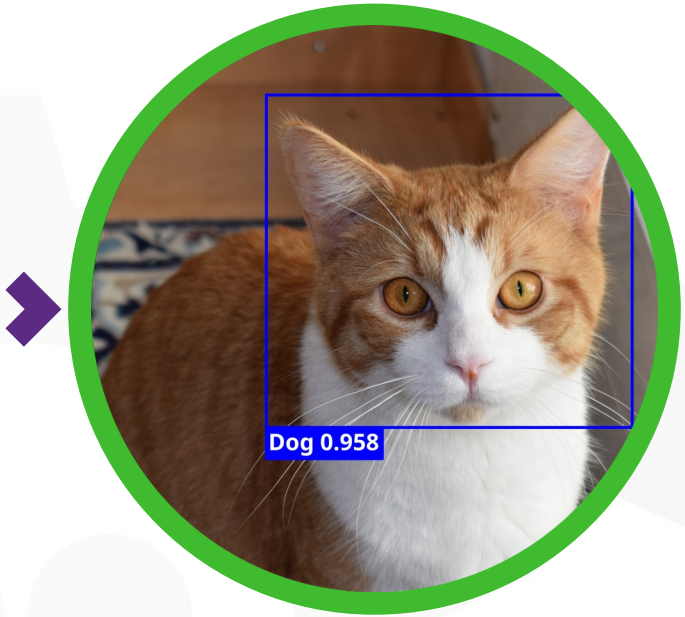
Video Output

- HDMI Output on RK3588 and RK3576 up to HDMI 1.4b
  - Includes HDMI audio and CEC
  - HDMI 2.0 and 2.1 support is a Work-in-Progress
- DisplayPort on RK3588
  - New driver that uses the bridge framework, not just downstream copypaste
  - Written and submitted by Rockchip themselves
  - RK3576 support in the same driver WIP, on list
  - USB-C alt mode still needs work for… USB-C reasons
- MIPI-DSI support for RK3588 and RK3576

Video Input

- HDMI Capture on RK3588 had its v4l2-based driver upstreamed
- New mainline MIPI-CSI drivers for RK3588 and RK3568/RK3566 by Michael Riesch
  - He had a talk on this work at FOSDEM yesterday, my condolences if you missed it
  - Partially merged, work still ongoing
- No Image Signal Processor support for RK35xx yet
  - Ergo no hardware debayering, inputs from CSI cameras will look very green
  - There is work on-going to bring up this hardware in mainline :)

Neural Processing Unit



- **Rocket:** A new mainline driver for RK3588's NPU
  - Written from scratch by Tomeu Vizoso
  - Hardware is derived from NVDLA design several generations removed
- Userspace implemented as a "Teflon" Tensorflow delegate in upstream Mesa
- Kernel side driver is a DRM_ACCEL driver
- NPU designs for RK3568/RK3566, RV1126B, RK3562, and RK3576 appear to be similar hardware
  - Not yet supported by mainline driver, however
  - Additional work needed

Multimedia

- Mainline hardware video decoding drivers use v4l2-requests cross-vendor stateless API
  - Not vendor's downstream "MPP" uAPI and library, leave FFmpeg drama at the door
- AV1 on RK3588 already enabled in mainline in 2024
- Detlev Casanova wrote RK3588/RK3576 H.264/AVC and H.265/HEVC decoder drivers
  - Merged just recently, first 8K decoder driver in mainline
- Jonas "Kwiboo" Karlman working on v4l2-requests support in FFmpeg, in review
- Upstream GStreamer should already support it

RK3576 Support

- Why is this SoC interesting? It's Cortex-A72/A53 and Bifrost!
  - Looks to be a "test bed" for taping out future hardware designs
    - Audio, UFS, PWM, FlexBUS, I³C all new
    - New in-house AV1 video decoder hardware, to replace licensed one in RK3588
    - Licensed ARM interconnect with coherent PCIe extensions 👀
    - New in-house JPEG encoder hardware (???)
  - Cheaper way to get NPU and video codec hardware that's close to what RK3588 has
  - Can piggyback on some of the RK3588 work that was done already
- Basic SoC support has landed (Clocks + resets, GPIO, power domains, thermal sensor, …)
- Many peripheral drivers needed no modification: ADC, SD, eMMC, PCIe, SATA, SPI, I²C, SPDIF TX, much of USB, Ethernet, …

RK3576 Support Cont.

- Rockchip themselves upstreamed the UFS driver to both Linux and U-Boot
- Driver for USB/DisplayPort Combo-PHY upstreamed
- Audio output driver upstreamed (by me!), needed some clock controller extending
- ARM Trusted Firmware had RK3576 support upstreamed by Rockchip
  - Meaning: BL31 for this SoC is now also open-source
- Sebastian Reichel is squashing suspend/resume issues in various Rockchip-related drivers, and making the watchdog bark to an appropriate degree
- Rockchip's Elaine Zhang is upstreaming CAN support, currently at v10 on the list
- Two months after sending an RK3588 Hardware RNG driver, I submitted an RK3576 one
- I'm still working on PWM output + capture as time allows

Miscellaneous Shout-Outs

- Jonas “Kwiboo” Karlman, for doing stellar work on mainline U-Boot for many Rockchip SoCs this year, like RK3576, RK3528, RK3506
- Heiko Stübner, for being mainline Linux’s Rockchip maintainer
- Rockchip employees: Kever Yang, Andy Yan, Damon Ding, Chayoi Chen, Elaine Zhang, Shawn Lin, Joseph Chen, and Ye Zhang
  - Thank you for participating in upstreaming and reviews ❤️
- Danct12 for working on mainline RK3566/RK3568 video output in U-Boot
- Everyone else who participates, too many to name!

Looking Into The Future 🔮👀

- RK3506 support patches for mainline Linux and U-Boot starting to trickle in
  - I assume we'll be able to boot this SoC with mainline this year
- U-Boot should probably market itself better, with prebuilt binaries for supported boards
- v4l2-requests stateless encoding uAPI a big unresolved question
  - If you are a company and your purse feels a little heavy, you can help
- Moving Rockchip to the generic interconnect subsystem would be nice
  - Latency/Bandwidth QoS handled by that instead of ad-hoc in device drivers
- Hoping we'll see more camera things in 2026
- Plenty of stuff left to do!
  - https://col.la/rk3588status and https://col.la/rk3576status
  - Make RK3576 drivers work on RK3562, RK3528, and RK3506
  - Submit a device tree for your board to mainline!

Questions?

For questions after the talk, join IRC:
#linux-rockchip @ Libera.chat

Thank you!

We are hiring - col.la/careers