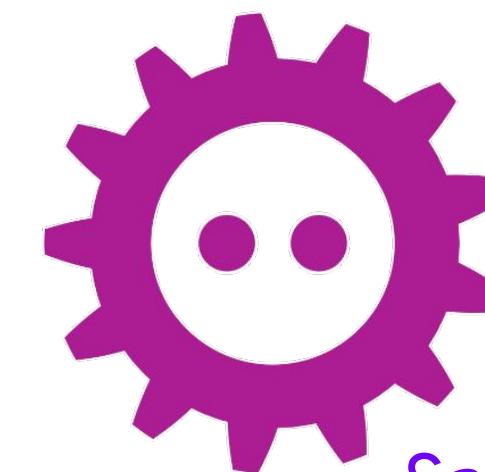




Arm Solutions at Lightspeed

Snapdragon 8 Gen 3 Mainline

From Day-1 Patches to Product Reality



FOSDEM

Sat 31 Jan 2026 - Track: FOSS on Mobile - Room: UB4.132



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Snapdragon 8 Gen 3

The Context

Introduction

Who am I ?

- Linux kernel hacker since 2006
- Linux Mainline contributor & maintainer since 2016
- Contributed 1,445 commits to 60 Linux releases
- U-Boot Mainline contributor & maintainer since 2017
- U-Boot Project Leadership Committee member
- Linaro Kernel hacker since 2022
- Dad of 2 kids & 2 cats

Recap

- 2 Years ago, I presented with:
 - Snapdragon 8 Gen 2 HDK
 - Running v6.8-rc1
 - PostmarketOS Edge
 - Freedreno with upstream Mesa



```
~ $ neofetch
narmstrong@qcom-hdk8550
-----
OS: postmarketOS edge aarch64
Host: Qualcomm Technologies, Inc. SM8550 HDK
Kernel: 6.8.0-rc1
Uptime: 18 mins
Packages: 1043 (apk)
Shell: ash
Resolution: 1920x1080
DE: GNOME 45.3
WM: Mutter
WM Theme: Adwaiata
Theme: Adwaiata [GTK2/3]
Icons: Adwaiata [GTK2/3]
Terminal: kgx
CPU: (8) @ 2.016GHz
Memory: 2786MiB / 10944MiB

```



Snapdragon 8 Gen 3 Support Status

- Supported as Linux v6.8-rc1
 - Display 
 - UFS, PCIe, USB & Bluetooth 
 - Thermal Sensors & CPU Frequency Scaling 
 - USB-C 
 - Suspend/Resume 
 - Crypto Accelerators 
- Work in Progress
 - Audio (Codec, USB-C Audio Accessory Mode)
 - DisplayPort Altmode ( on Gen 1 & Gen 2)
 - DSPs (Modem, Compute & Audio DSP) ( on Gen 1 & Gen 2)
 - USB-C PD/Charger ( on Gen 1 & Gen 2)
 - GPU ( on Gen 1 & Gen 2)

The Goals

**Moving from *console=ttyMSM0* to a daily-driver capable GUI.
Make usable for personal usage & commercial products.**

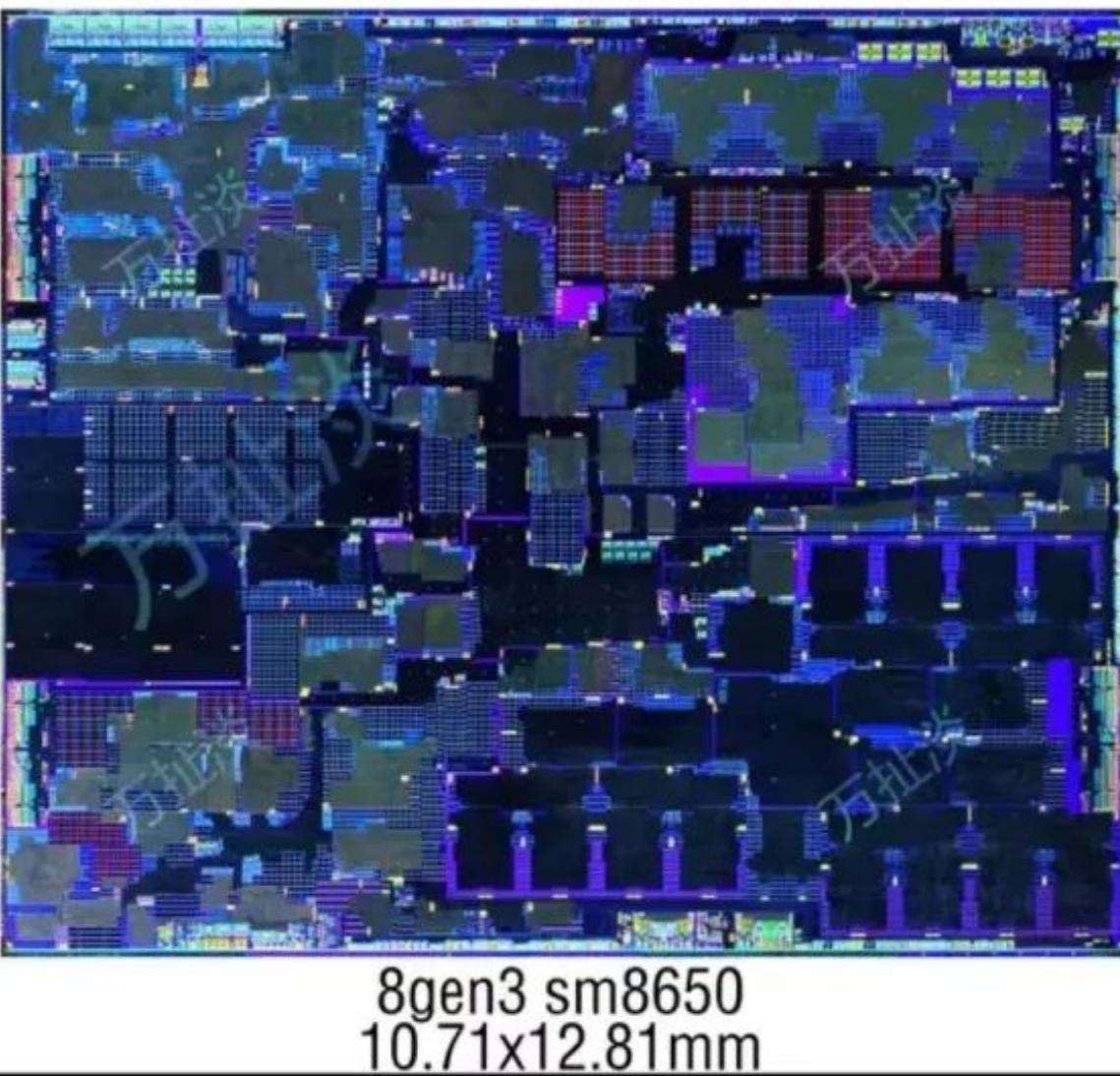
Upstream is not just for dev boards anymore :-)

- My first attempt was with the Amlogic SoCs:
- SBCs with official mainline Linux based OS
 - will boot any aarch64 UEFI distro with no efforts

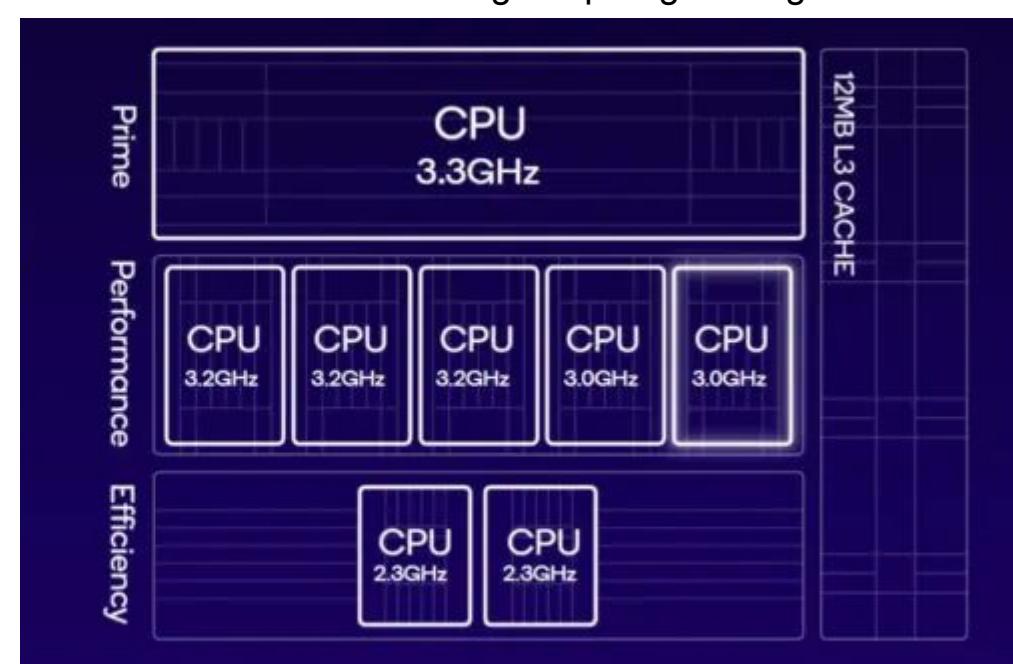
SM8650 (Lanai) SoC Overview

Overview of the beast

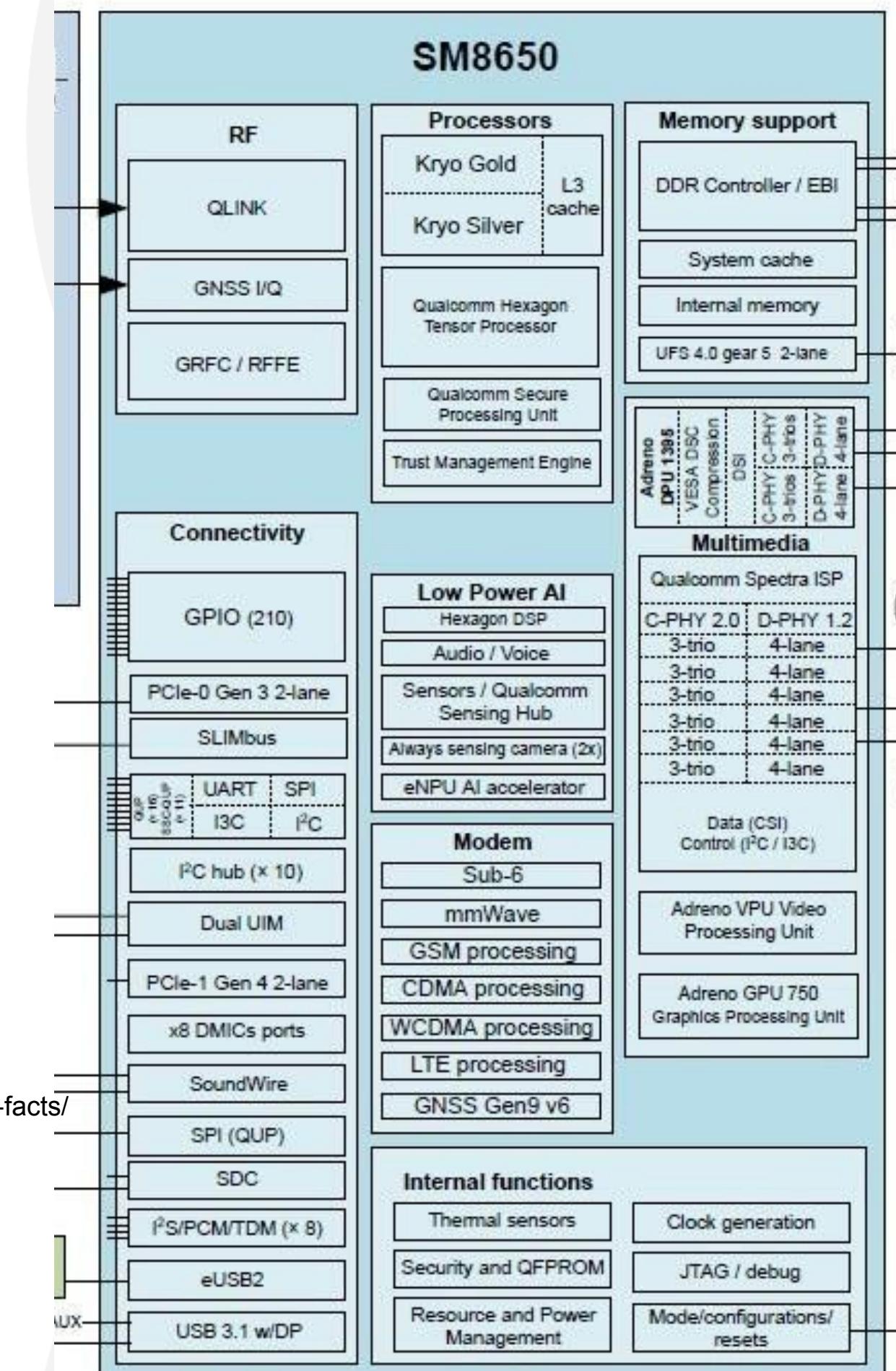
- 8 Cores
 - 1x 3.3GHz (Cortex-X4)
 - 3x 3.2GHz (Cortex-A720)
 - 2x 3GHz (Cortex-A720)
 - 2x 2.3GHz (Cortex-A520)
- Adreno 750 GPU & DPU
- 8k H265/VP9/AV1 VPU
- High performance ISP
- 3x Hexagon DSP
- 2x PCIe Gen3 & Gen4
- USB-C+PD with 4lanes DP
- UFS 4.0 gear 5



<https://innogyan.in/2024/04/08/disassembling-snapdragon-8s-gen3-unveils-surprising-facts/>



Source: Qualcomm



<https://bbs.16rd.com/thread-610554-1-1.html>

v6.19-rc Mainline Status

Supported:

- Display: DSI w/ DSC, DisplayPort Altmode
- Adreno 750 GPU (Vulkan 1.4)
- Camera support
- UFS 4.0 w/ MCQ
- PCIe Gen3 (WiFi 7) & Gen4 (NVMe)
- USB-C w/ PD Charger, USB3, 4lanes DP Altmode, Audio Accessory mode
- Thermal Sensors & CPU Frequency + Interconnect Scaling
- DSPs (Modem, Compute & Audio DSP)
- System Suspend/Resume
- Crypto Accelerators

v6.19-rc Mainline Status

Work In Progress:

- Advanced Display support
 - Dual high resolution display with compression
 - High resolution/framerate Concurrent Writeback
- Advanced Camera features
 - single PHY - multi sensor support
- Advanced VPU features
 - H264/H265 encoding parameters
 - AV1 decoding support
- Advanced GPU Support
 - Scheduler support for low-latency features



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The Upstreaming Journey

Mainline hardware support

Architectural shifts from SM8550

- Snapdragon 8 Gen 2 was the starting point
- A lot of similarities between 2 SoCs
- Key Architectural shifts:
 - Different CPU cores layout, much more powerful set
 - Goodbye AArch32 !
 - GPU substantial upgrade (up to +25%) and more features
 - NPU can handle much more processing
- But small gaps for:
 - DSP
 - Display Engine
 - Connectivity (PCIe, USB)
 - UFS

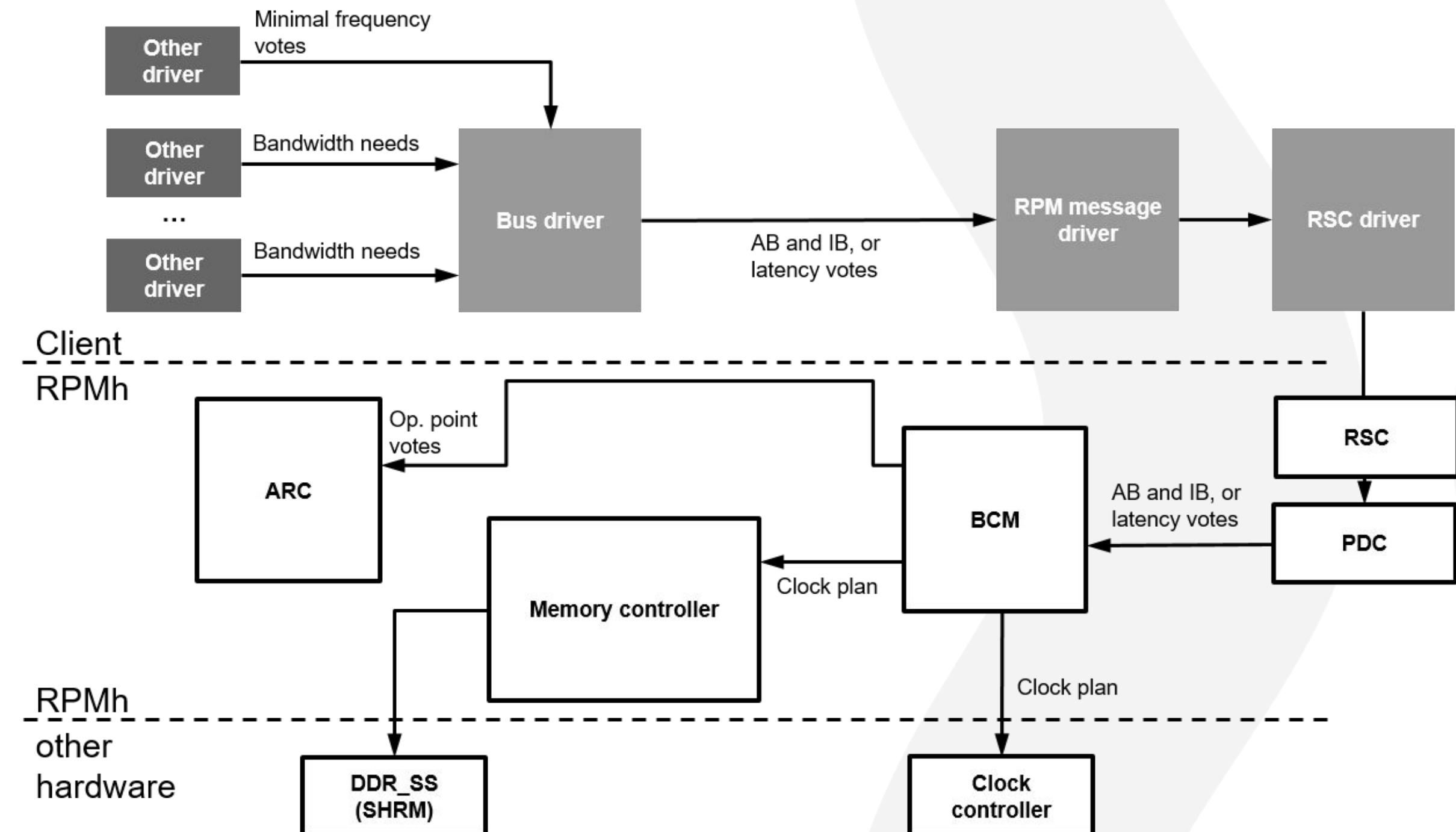
Already well supported

- Day-1 support was facilitated by current state
 - SM8550 had boot to UART on Day 1
 - Thanks to the SM8550 work, **we had boot to UI on Day 1 !**
- Most changes were Device Tree bindings
- Initial code changes were:
 - Interconnect & Clock drivers
 - PHY configuration tables
 - Hardware description
 - DSP startup sequence
- 59 patch sets for initial support (with GPU and Touch support)
- Average of 2 patchset revisions

Power Management & Interconnects

Resource power manager hardening (RPMh)

- Central resource manager
- Handle votes from all subsystems (ARM, DSP, GPU, ISP, ...)
- Handles configuration of:
 - Network-on-Chip interconnect
 - Voltage Domains (ARC)
 - Power Domains
 - Voltage Regulators (VRM)
 - Memory controllers



https://docs.qualcomm.com/doc/80-88500-4/topic/47_Frequency_management.html

Power Management Challenges

- We don't manage most of the resources from Linux
 - We don't “speak” to PMICs for the Voltage Domains and Regulators
 - Most of the resources are handled by the RPMh
- The ARM subsystem shares resources
- RPMh will coordinate the votes
- Only some clocks are in control on Linux
 - I/O Peripherals, Display, GPU PLL, VPU PLL
- Makes power management challenging
 - Our vote doesn't necessarily reflect what's applied
 - Makes it hard to achieve very low power consumption
 - Makes it harder to achieve “System Power Collapse” / “CX Retention”

The Adreno 750 GPU

Turnip

- The big deal is in Userspace
- “turnip” is the Vulkan Freedreno implementation
- See XDC’s 2025:
- “Turnip: Improving performance without compromising correctness” talk

Quick update on Turnip

- Adreno 750 is the main optimization target
- With a few outstanding MRs, Turnip supports almost everything HW is intended to support
- Performance is on par with the prop driver on many d3d11 titles
- Correctness is better than prop driver



Adreno GMU

- GPU Power management as again not directly handled by Linux
- GMU stand for “GPU Management Unit”
- Responsible for:
 - internal clocks management
 - power management
 - RPMh performance voting
 - voltage fine tuning
 - runtime suspend/resume
 - Inter Frame Power Collapse
- Consists of a firmware to load

Adreno Speedbins

- SoCs Performance are tied to “Speed Binning”
- Operating Performance Points are device specific
- Qualcomm fills “speedbins” tables in factory
 - Previously consisted of a single index:
 - 0 means all OPPs are supported
 - 1, 2, ... will match against a opp-supported-hw mask in the Device Tree
 - Newer SoCs gets a combinations of "feature code" (FC) and "product code" (PC)
 - Need to convert sets of FC and PC values to a speedbin index
 - Today we only support the common OPPs
 - Would need complex kernel logic to handle high OPPs with speebin index

Freedreno Driver

- Features added in the Kernel for GPU support
 - GMU direct bandwidth vote
 - ACD (power regulator finetuning per OPP)
 - Inter Frame Power Collapse (IFPC)
 - GPU Preemption
 - Scheduling enhancement
- Work in progress:
 - Speedbin support for A740+
 - LPAC for CL low latency processing

Hexagon DSPs & Remoteproc

Concurrent Subsystems

- DSPs are concurrent & independent subsystems
 - aDSP: Application DSP handling Audio, USB-C PD, Battery Management, Sensors, ...
 - cDSP: Compute DSP to offload compute operations
 - MPSS: Modem Processing Subsystem
- Startup is (no more in EL2) handled by Hypervisor
 - Relies on the Peripheral Authentication Service
 - Firmware files are authenticated
 - Setups Memory zones protections (dedicated, shared)
 - Starts DSP
- Communication is done via IPCC / SMP2P
 - Mailbox based + SMEM shared memory for communication
 - Remoteproc RPMSG implemented in top

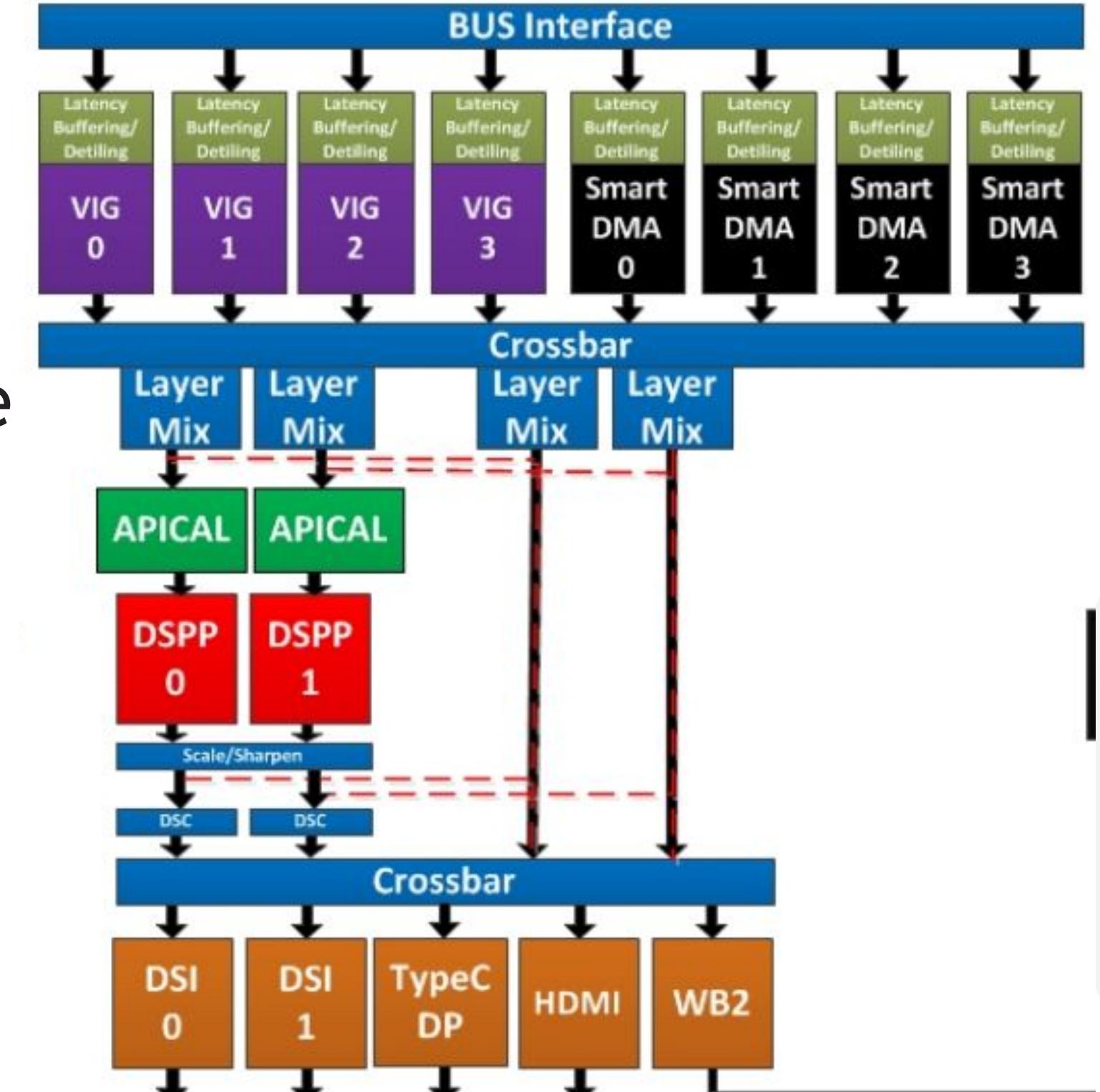
DSP Linux clients

- Major users of Qualcomm RPMSG
 - Audio path via Q6APM / Q6PRM
 - USB-C PD via UCSI over PMIC-GLINK
 - Modem support via QRTR & QMI
- USB-C PD allows supporting PD Altmode
- Sensor support is work in progress

Display & Multimedia

Display Processing Unit

- Scalable and highly configurable display engine
- Two DRM backends:
 - MDP4/5 legacy implementations
 - DPU1 modern implementation for msm8917+
- DSI and DisplayPort common support
- DPU1 is the backend we use
 - Constant evolution for support new SoCs
 - Supports most common usecases
- Advanced support missing:
 - DSI Command mode with VRR
 - DSI Dynamic rate change
 - Display Port DSC
 - ...



<https://bbs.16rd.com/thread-466385-1-1.html>

Video Processing Unit

- Previously supported with the Venus driver
- Qualcomm introduced Iris, new redesign from the ground up
 - With SM8550/SM8650 the VPU uses a more V4L2-compliant protocol
 - Simpler to redesign from scratch than to refactor
 - Reduced to the minimal support (SM8250 & SM8550) with decoding
 - Added new SoCs and features iteratively
- Features:
 - V4L2 Stateful M2M codec, supporting decoding and encoding
 - H.264, HEVC, VP9 and VP1 is in review
 - Well tested with Fluster, v4l2-compliance, Gstreamer & FFmpeg
- Gotchas
 - Firmware: some devices will require specific signing scheme

Camera Subsystem

- The Titan vs. The Ant (CAMX vs. CAMSS)
 - Qualcomm's downstream camera stack is a distributed computing system
 - Involves an userspace service, offloading to the CDSP, and closed-source ISP
 - CAMSS handles the Spectra ISP mostly as simple DMA, move data from the sensor to RAM
- SM8650 features the "Titan" ISP (Spectra 780)
 - incredibly powerful
 - but Mainline only scratches the surface...
- Supported features:
 - CSIPHY / CSID: MIPI C-PHY/D-PHY setup and demux the streams
 - VFE (Video Front End): using "RDI" (Raw Dump Interface) to write raw Bayer data to RAM
 - Sensors: Standard V4L2 sub-device support for I2C sensors
- Gotchas:
 - No Hardware ISP Processing
 - Userspace (specifically libcamera) must perform image processing on the CPU or GPU



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The Bootloader Story

Qualcomm's Boot Flow

- PBL -> XBL -> Gunyah -> ABL -> Linux
 - PBL is the ROM, load the XBL binary
 - XBL (Extensible Boot Loader)
 - Setups trustzone (QTEE)
 - DDR training, UFS setup and clock setup
 - Starts the UEFI Core
 - Gunyah (Type-1 Hypervisor) takes over EL2
 - ABL, an UEFI Application implements the Android Boot Protocol
 - Implements Fastboot
- ABL can be replaced, or extended to continue UEFI boot
 - Making the Snapdragon (almost) behave like a PC
- For development, ABL & Fastboot is used as-is

Upstream U-Boot on SM8650

- U-Boot has been extended to boot in EL2 like Linux
- Extended hardware support:
 - UFS
 - PCIe
 - USB3
 - DSI Display support is in progress !
- When loaded by ABL, can expose it's own UEFI implementation
 - Making the Snapdragon (**really**) behave like a PC
 - Supports UEFI capsule
- Could replace ABL
 - U-Boot as EFI payload posted 1y ago



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Product Reality

Products using SM8650



Ayaneo Pocket S2

- Ported to mainline Linux !
- Variant of the Qualcomm Reference Device
- Main differences:
 - Specific 2K Panel, with specific power regulators
 - Analog triggers/joysticks internally connected via USB
 - Slightly different audio connection
 - No camera
- v6.19-rc7 branch with 22 changes on top!
 - 3 are DT Bindings changes
 - 4 defconfig
 - 8 changes for all platforms
 - 7 Ayaneo Pocket S2 specific changes

<https://ayaneo.com/product/AYANEO-Pocket-S2>



OS Integration

- Ayaneo Pocket S2 integrated into PostmarketOS Edge!
- Thanks to Sunflower2333
- Uses the systemd-boot images
- Based on linux defconfig
- Uses Sunflower2333 ABL
 - Allows booting with EFI
 - Boots over an SDCard
 - Dual-boot with Android !

Add initial support for Ayaneo Pocket S2

Merged Neil Armstrong requested to merge superna9999/pmaports:sup... into master 1 week ago

[Overview](#) 34 [Commits](#) 4 [Pipelines](#) 11 [Changes](#) 10

Initial support for the Ayaneo Pocket S2, booting using EFI with abl2esp [1] or ABL with ESP boot support [2].

The Ayaneo Pocket S2 is a Snapdragon 8 Gen 3 based gaming device, it has a 2k 60fps LCD panel, internal UFS, complete keypad connected via a PCIe USB Controller, SD Card slot, WiFi and Bluetooth.

The device runs Android by default, but with the help of a different ABL, it can boot any distro via EFI.

The device is available in a variety of memory, ufs sizes and colors.

Product page: <https://www.ayaneo.com/goods/9344084410613>

[1] <https://github.com/sunflower2333/abl2esp>

[2] <https://github.com/sunflower2333/abl-build-ci>

Signed-off-by: Neil Armstrong neil.armstrong@linaro.org

Edited 1 week ago by Neil Armstrong

[https://wiki.postmarketos.org/wiki/Ayaneo_Pocket_S2_\(ayaneo-pocket-s2\)](https://wiki.postmarketos.org/wiki/Ayaneo_Pocket_S2_(ayaneo-pocket-s2))

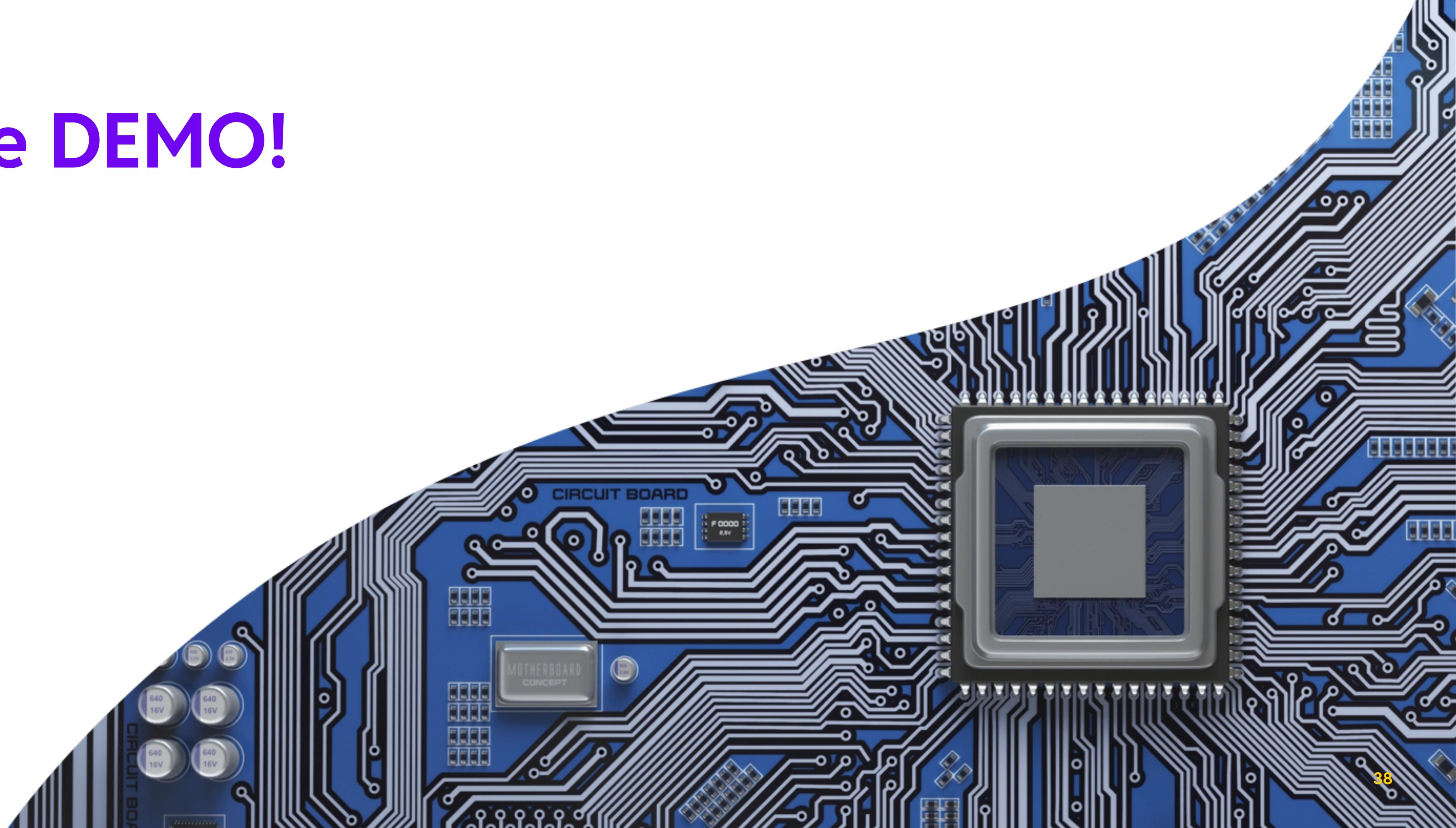


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Live Demo !

& Conclusion

Live DEMO!



Technical Post-Mortem

The Good

- Current mainline support is solid
- Commonality with SM8550 (Gen 2) sped up initial bring-up
- Qualcomm helped a lot upgrading driver support
 - DSP
 - Display
 - Video Decoding/Encoding
- Upstreaming velocity is high !
 - Bringing up mainline device to boot UI is fast

The Bad

- Firmware dependency makes integration hard
- Qualcomm uses to ***not*** upload firmwares
 - This is slowly changing, thanks !
- Regression testing on consumer hardware is lacking
 - A lot of bugs occurs and are detected late

The Ugly

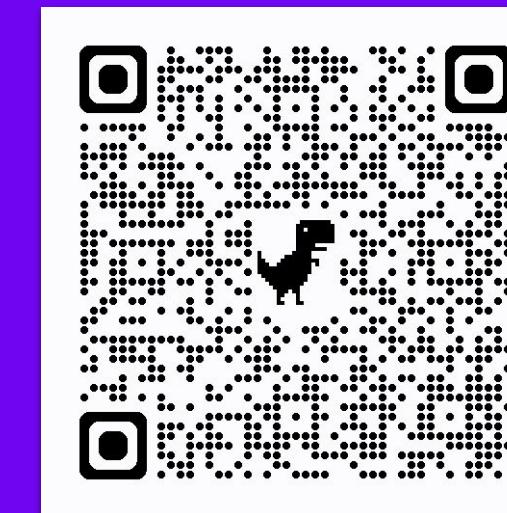
- Mainline linux supports the SoC well, not devices
- A lot of features are lacking
 - Advanced Panel support
 - Advanced display support (color conversion, ...)
 - Advanced Camera features
 - Reliable low power suspend
 - Soundwire features
 - Audio DSP features
 - ...

Summary & Next Steps

- SM8650 is fully usable on Mainline today !
- Consumer devices like Ayaneo Pocket S2 are excellent dev platforms
 - Easier and cheaper than development platforms
- Call to Action:
 - Pick up a device
 - build the DT
 - and submit patches!
- Status: <https://linux-msm.github.io/mainline-status/>
- Join us on #linux-msm !

Thank you

Slides:



 <https://gitlab.com/superna9999>

 <https://social.linux.pizza/@superna9999>



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