



Second chance: Upgrading devices from Android 9 to Android 14

A real case of using open-source software to save thousands of old devices from being disposed and replaced

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Android for RPi

Public AOSP repositories for Raspberry Pi

<https://github.com/RTAndroid>

<https://github.com/android-rpi>

<https://github.com/emteria>



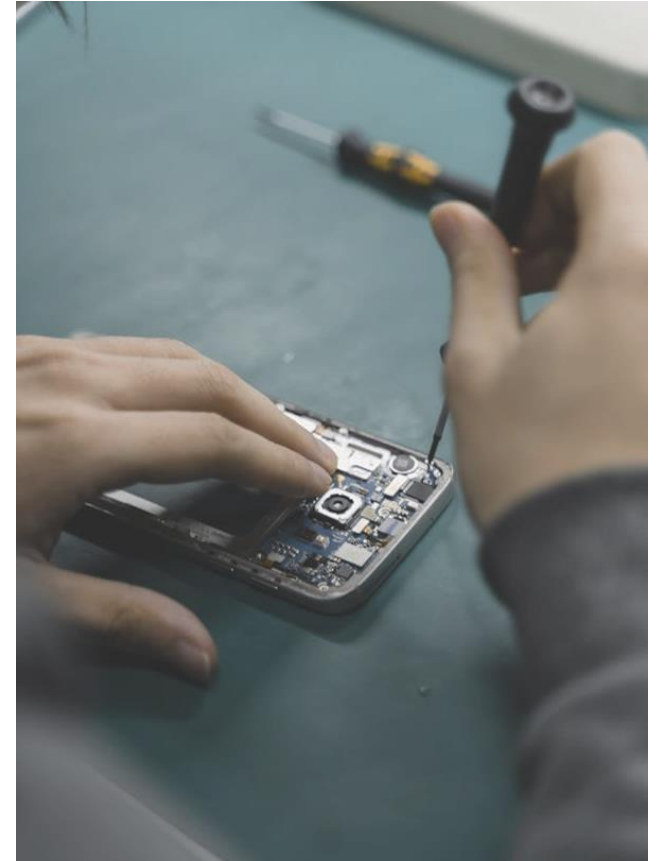
emteria GmbH

- Providing Android support for SBCs and custom devices
- Validating and performing security audits for Android OS
- Offering over-the-air updates & device management services

Software Obsolescence is a Problem

Why upgrading software on existing devices is important

- Hardware manufacturers make money by selling (new) devices
- Rapid Android release cycles → shorter device support lifespans
- Security vulnerabilities in unmaintained Android releases
- EU regulations & compliance for device longevity
- Economic & environmental benefits of upgrading instead of replacing
- Main project goals:
 - Upgrade an existing device from Android 9 to something newer
 - Reduce dependencies from the original device manufacturer
 - Use open-source components where possible

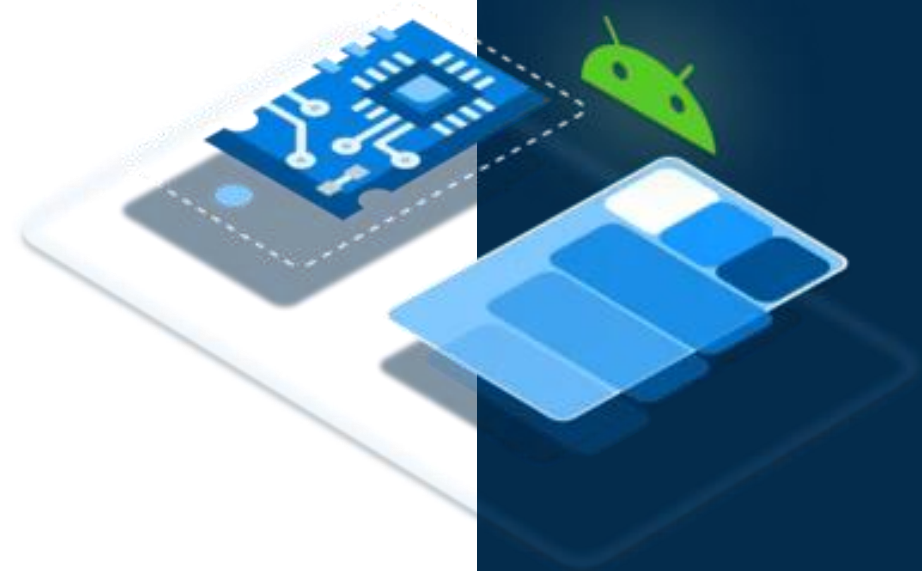


Hardware Specs

Specs of the device and usable interfaces

- Test device available for our experiments
 - No schematics, no JTAG, but UART is available
 - Unlockable bootloader, working fastboot
- Popular Qualcomm Snapdragon SoC from 2018
- Lots of peripherals
 - Media: multiple cameras, audio
 - Wireless: WIFI, BT, NFC, radio
 - Extras: fingerprint reader, sensors

A good start!



Software Specs

Contents of the original Board Support Package

- Original Android version: 9
- Original Kernel version: 4.9
- Proprietary BSP in a single ZIP file
 - Repo manifest with all projects: no
 - Git history for old changes: no
 - Technical support from ODM: no
 - Support from client's in-house expert: yes

A huge win!



Research of Open-Source BSPs

Gathering information about similar devices and BSPs

- Search for compatible devices and BSPs online
 - Same or pin-compatible SoC
 - Similar kernel version
- Popular open-source Android distros (in alphabetical order):
 - AOSPA: <https://github.com/AOSPA>
 - CalyxOS: <https://gitlab.com/CalyxOS>
 - /e/OS: <https://gitlab.e.foundation/e>
 - GrapheneOS: <https://github.com/GrapheneOS>
 - LineageOS: <https://github.com/LineageOS>
 - XDA Forums: <https://xdaforums.com>



Result Evaluation

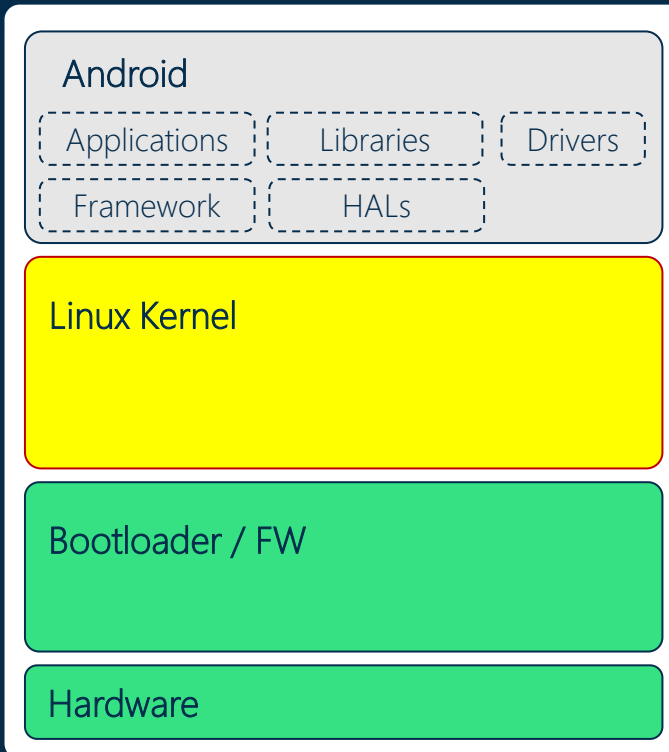
Deciding which BSP is the best match

- Create a list of maybe-compatible open-source BSPs
 - Device name and SOC information
 - Kernel and Android version(s)
 - Development status
- Pick the most promising one
 - Closest match for the Linux kernel: same version!
 - Newest Android version: 14!
 - Similar peripherals: more or less
 - Officially supported by LineageOS: yes
 - Actively maintained: yes

Device	SOC	Android	Kernel	Status
[redacted]	[redacted]	Android 9 Android 10 Android 11 Android 12L Android 13	4.9	continued
[redacted]	[redacted]	Android 7 Android 8.1 Android 9 Android 10 Android 11	3.18	discontinued
[redacted]	[redacted]	Android 9 Android 10 Android 11 Android 12L Android 13 Android 14	4.9	continued
[redacted]	[redacted]	Android 10 Android 11 Android 12L Android 13 Android 14	4.9	continued
[redacted]	[redacted]	Android 7.1 Android 8.1	3.18	continued
[redacted]	[redacted]	Android 2.3 Android 9 Android 10 Android 11 Android 12L Android 13	4.9	continued
[redacted]	[redacted]	Android 7.1 Android 8.1 Android 9	4.9	discontinued

Step #1: Linux Kernel

Preparing the device tree and the defconfig



- Goal: Make the original kernel compile with the new BSP
 - Possibility 1: fully replace LOS's kernel with original kernel
 - Possibility 2: migrate original DT & drivers into the LOS kernel

← This was easier in our case.
- Difficulties compiling the original kernel
 - Dependencies on LOS' makefiles and defines
 - Different toolchains in original BSP and in new BSP
- Keep the device tree small

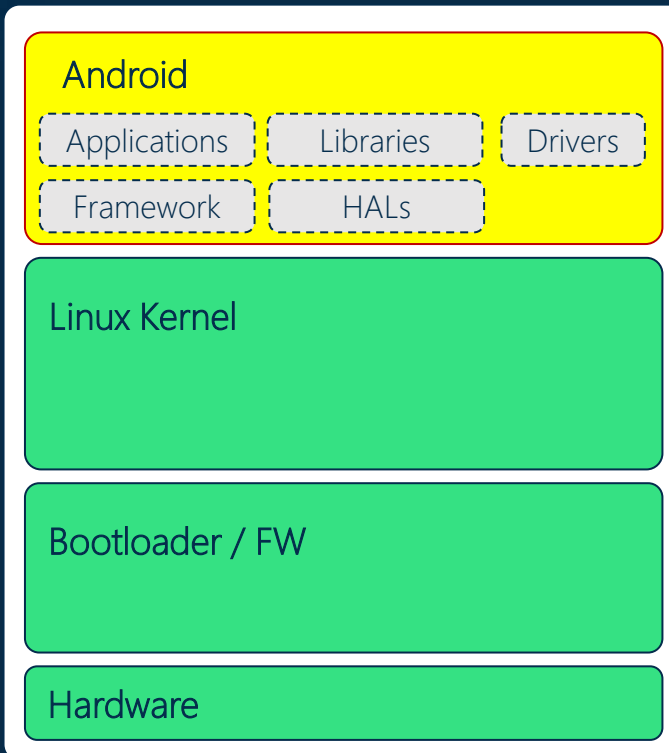
← Mainly early partition mounts.

 - Add Android-specific DT definitions
 - Disable all non-critical drivers in the defconfig

← Like audio, touch, radio, networking.

Step #2: Android Boot

Let the device boot for the first time



- Goal: Get Android to boot to the main UI
 1. Make device config similar to the original one
 - ← Example: make the partition layout compatible.
 2. Make device config as small as possible
 - ← Example: disable all non-critical features and HALs.
 3. Make device config as permissive as possible
 - ← Example: disable security (AVB, SELinux, etc.)
- Repeat the cycle:
 - Compile, flash, boot, record logs
 - Fix the most critical issue which causes freezes or boot loops

Step #3: Userspace

Debugging remaining features step by step



- Goal: Bring back features and peripherals

Start with Touch, USB, ADB, WIFI, ...

- Continue debugging and fixing step by step
 - Record an error trace for a specific component
 - Figure out how it is configured in LOS
 - Figure out how it was configured in the original BSP
 - Re-enable kernel driver config and DT entries
 - Make corresponding adjustments or replace HALs/blobs
- Cleanup and finalize
 - Enable SELinux and extend product-specific policies
 - Replace signing certificates

Conclusion and Future Work

Key takeaways and next steps

- This project was successful, but it is not yet complete
- We will continue working with Lineage repos and contribute where possible
- Huge dependency on availability of code and knowledge
 - Would not be possible without open-source software → plays huge role for device longevity
 - Difficult without ODM support → we had help from an expert familiar with this kernel
- Call to action for everyone
 - Contribute to open-source projects
 - Upgrade existing devices



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