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Building Embedded Systems with AOSP

Why You Should Consider, Best Practices and Pitfalls

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Augenblick, verweile doch! Du bist so schön! Du erzählst von denen, die Liebe gefunden, den Schmerz überwunden, das Glück verschwendet, ihr letztes Hemd verpfändet. Zeigst die, die den Täter geschnappt, in die Liebesfalle getappt, den Drachen besiegt und das wilde Leben geliebt. Bringst Versteckte ans Licht, scheust selbst Unbequemes nicht, gibst kleinen und großen Gestalten ein Gesicht. Du lässt Sirenen singen und so manchen um Fassung ringen. Machst aus der unerhörten Begebenheit einen Moment für die Ewigkeit. Bist manchmal schön wie ein Traum, spielst mit Zeit und Raum. Schickst Helden auf Reisen, musst nichts beweisen und steckst doch voller Wahrheiten. Zeit für Geschichten mit tolino shine 4.
Wait, stay a while! You are so fair! You tell tales of finding love and overcoming pain, stories of having everything and losing it again. You show us who caught the thief and fell into love's trap, who battled with the dragon, or who left and never came back. You take on every challenge, bring dark secrets to the light, and always fill each character with detail and with life. You make sirens sing out loud while a hush goes through the crowd. You take the most terrific tales and tell them line-by-line, sometimes you are like a dream that plays with space and time. You send heroes off on journeys, and have nothing more to prove, and always entertain us, or help us find the truth. Story time with tolino shine 4.
Augenblick, verweile doch! Du bist so schön! Du erzählst von denen, die Liebe gefunden, den Schmerz überwunden, das Glück verschwendet, ihr letztes Hemd verpfändet. Zeigst die, die den Täter geschnappt, in die Liebesfalle getappt, den Drachen besiegt und das wilde Leben geliebt. Bringst Versteckte ans Licht, scheust selbst Unbequemes nicht, gibst kleinen und großen Gestalten ein Gesicht. Du lässt Sirenen singen und so manchen um Fassung ringen. Machst aus der unerhörten Begebenheit einen Moment für die Ewigkeit. Bist manchmal schön wie ein Traum
138 / 367
tolino


BOSCH
SCAN
GLOBAL OBD II
SERVICE TASK
LAST 30 VEHICLES
SOCKET
KTS 250
Powered by ESI[tronic]


powered by
azena

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Why you should consider AOSP for embedded systems

An introduction

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What's the Android Open Source Project?

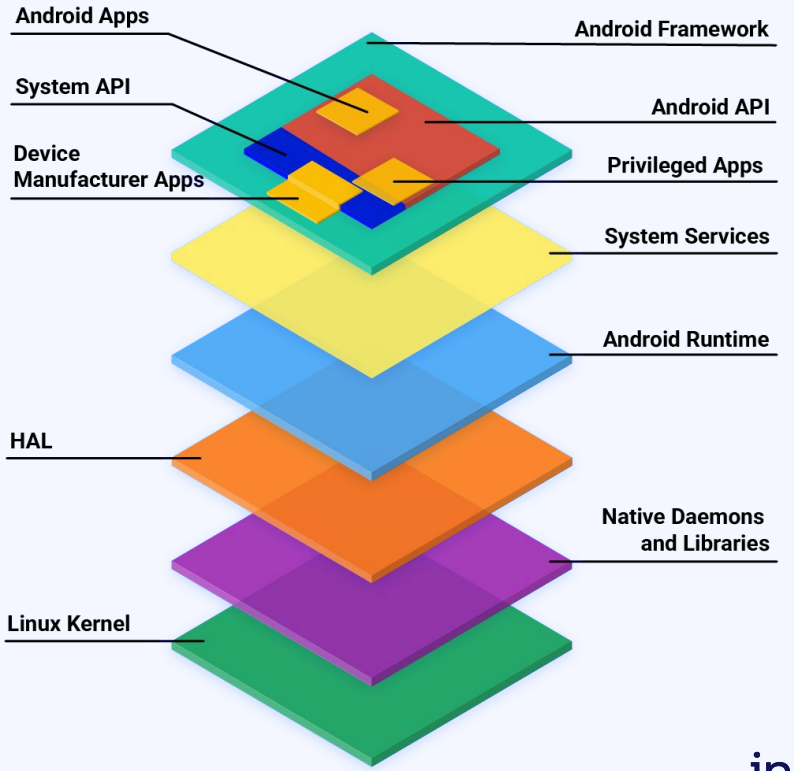
Two levels of compatibility:

AOSP compatibility
defined by Compatibility Definition Document (CDD)

Android compatibility
CDD plus
- Vendor Software Requirements (VSR)
- Vendor Test Suite (VTS)
- Compatibility Test Suite (CTS)

Additional step:
Licensing Google Mobile Services (GMS)

- Google Apps (Youtube, Maps, Gmail, ...)



https://source.android.com/docs/core/architecture

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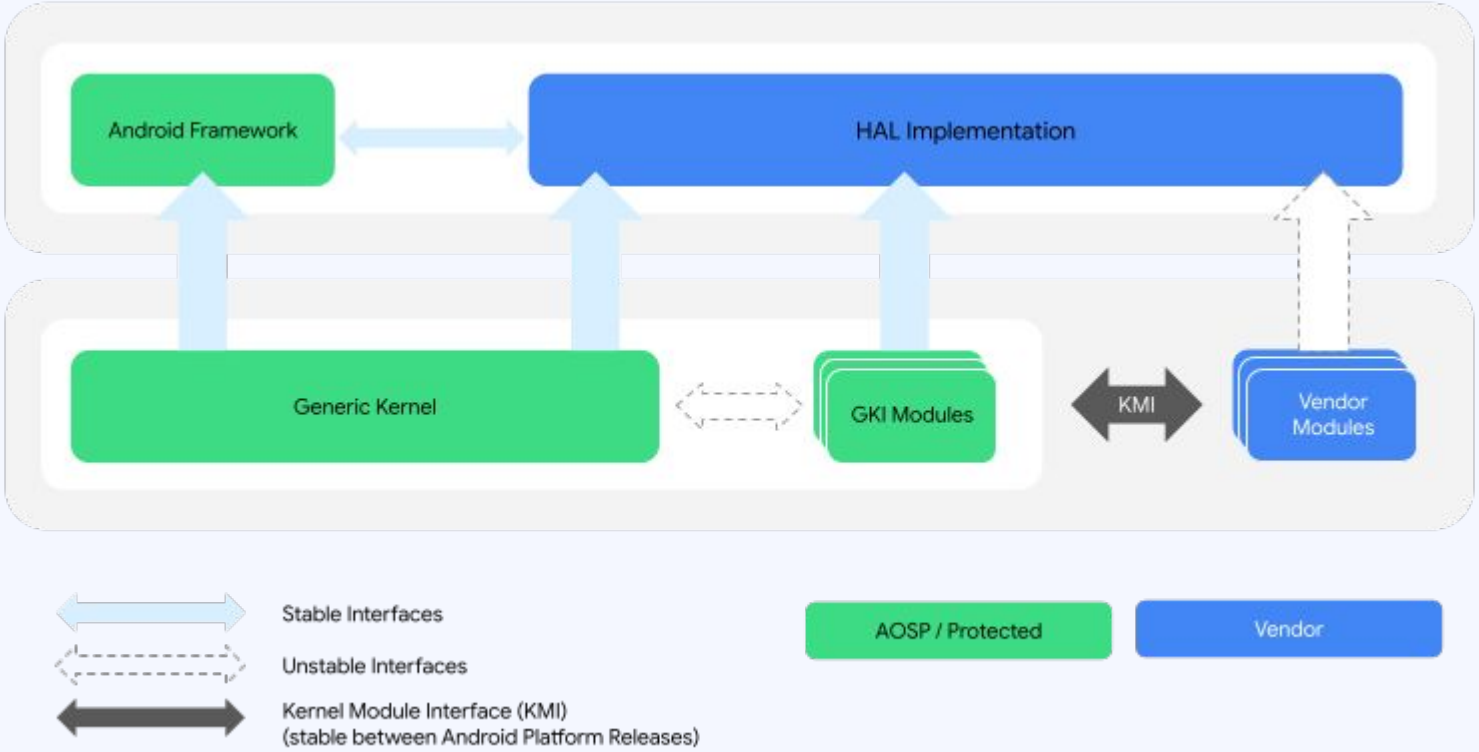
Kernel philosophy



https://source.android.com/docs/core/architecture/kernel

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What the AOSP already does for you

The pro side

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What’s included from a system engineers perspective

- provides a proven, stable and solid open source **platform**
- based on Linux
- secure runtime environment for untrusted apps
- graphics, video and media support
- connectivity
  - WiFi
  - Bluetooth
  - NFC
  - ...

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What’s included from a system engineers perspective

- generic kernel image and defined module interface
- sophisticated Hardware Abstraction Layer (HAL)
- defined APIs between layers
  - System API
  - Android API
- support for multiple target device types
- optimization for power-efficiency

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What’s included from a security perspective

On system level

- SELinux
- ASAN and sanitizer in general during build time
- dm-verity
- hardware keystore (Trustzone)
- OTA (over the air) update mechanism with A/B concept
- read-only system filesystem

What’s included from a security perspective

On app level

- sophisticated app concept with
  - secure runtime for untrusted apps
  - app isolation

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Benefits for app developers and users

- an UI/UX concept people are already familiar with
  - platform focuses on UX!

- well-known app developer ecosystem
  - standardized **APIs** with a good abstraction level
  - extensive set of system and third-party **libraries**
  - pretty good and in depth **documentation**
  - large eco system of existing apps
  - lots of *good* Android **app developers**

The downsides of using AOSP

Pain points of the AOSP itself

- very extensive code base
  - > 200 GB source code
  - needs potent build hardware and lots of compile time
- pretty high target system requirements
- high and increasing complexity
  - steep learning curve
  - lots of layers and abstractions within the system
- internals are continuously morphed
- build system chaos / changing build systems
- painful version updates

Google, SoC vendors and OEMs

- AOSP is open-source but hard to contribute for people outside
- branding as Android and shipping Google apps require certification
- non-transparent partner ecosystem and license agreements

- SoC vendors and OEMs are not interested in selling low and medium quantities

- BSPs from SoC vendors
  - may need for a NDA to access the BSP
  - vendor specific, non-standard additions and build scripts
  - binary blobs (check licenses!)
  - quality depends on vendor

General downsides

- focus on target device types
  - no support on other types or use-cases (e.g. headless)
  - clear focus on phones and UI-based devices (e.g. cars)
- intended for large volume products or own ecosystems
- OTAs needs own servers, management and good test runs
- few AOSP system engineers available

When is using the AOSP a good choice?

And when not?

Consider using the AOSP if...

- you want to build an **ecosystem**, that
  - targets various devices
  - runs on various hardware targets
  - is maybe open for third party app developers
- you need an app concept with strong isolation of untrusted apps
- you need the advantages of a sophisticated touchscreen UI
- you want to utilize the advantages of the media framework
- you need a GPL free system layer

Don’t use the AOSP

- if the overhead of AOSP does not give you clear advantages e.g.
  - you don’t need a graphics/media stack at all
  - you don’t care about the app concept
- if you’re performance sensitive e.g.
  - boot time needs to be extremely short
- if you have a “small” use-case
  - with limited hardware resources
  - which is cost-sensitive
- if you don’t have the person-power to maintain a full-blown AOSP system
  - you are strongly dependent to a SoC vendor (BSPs)
  - no open community support

Best Practices, Recommendations and Pitfalls

Getting started

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Working with the source

- Use a code search engine like https://cs.android.com/android

- Make developing within AOSP smoother by importing it as Android Studio Project
  - *source build/envsetup.sh*
  - *lunch <your-build-config>*
  - *make idegen && development/tools/idegen/idegen.sh*
  - Open android.ipr with Android Studio
    - Wait until indexing is finished
    - If there are issues, see https://github.com/flutter/flutter-intellij/issues/1735#issuecomment-376918296

https://cs.android.com/android/platform/superproject/+/master:development/tools/idegen/README

Working with the source

Working with the AOSP tree in Android Studio

- Allows general AS features (mostly for Java, but as well for native code)
  - Helps with type information
  - Finds usages
  - Nice for system development (Java services, native code, ...)
- Pretty comfortable for executing tests
  (gradle build files needed!)
- Allows (Java) debugging from IDE

- No support for building the whole AOSP from the IDE!

Select a platform to start with

Phone, tablet, development board or emulator?

- Just want to start working with AOSP? Use a Google device!
- Emulator is limited in case of working with external hardware, kernel and drivers
- Dev boards are often outdated or not longer available (officially in AOSP supported ones)
- Use the target platform for your product if possible (Reference Board)
  - Be aware of availability issues
  - Differences between reference design and actual device platform
  - Vendor flavoured AOSP BSPs are … different

Vanilla AOSP vs. Board Vendor BSPs

Vanilla AOSP

- Supported by Google
- Standard way of working (as documented)
- Latest versions available
- In general not suitable to build products
  - Google HW not available
  - Dev boards not suitable for production

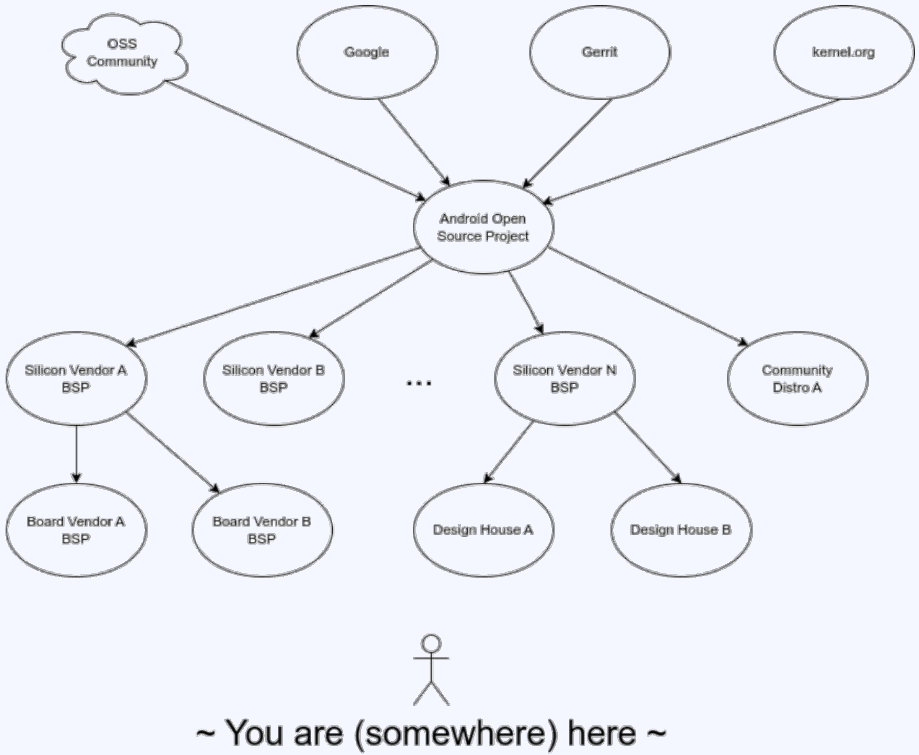
Great to start

Board Vendor branded BSPs

- Supported by vendor
- Often with custom build scripts
- Diverging workflows (e.g. Qualcomm Kernel Build)
- Slow build due to custom logic
- Not all versions for all dev boards and platforms
- Updates are delayed
- NDAs, mostly always hard getting access

Needed when building products

BSPs from h*ll



https://www.opersys.com/downloads/cc-slides/embedded-android/slides-main-clean.html#/13

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Best Practices, Recommendations and Pitfalls

Tools and Workflow

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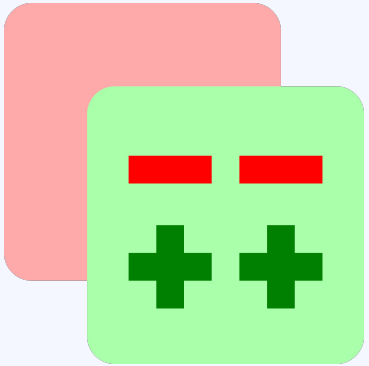
Version control and working in a multi-repo project

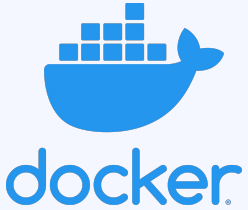
Use **Gerrit Code Review**!



- proper handling of cross-repo commits
- enforces a clean way of working
  - e.g. with proper, meaningful commit messages
  - nice for code reviews
  - good overview of open change requests, open reviews, ...

Gerrit is a pretty ugly frontend in contrast to GitLab, GitHub, ...
but the best tool when working in a multi-repo project as AOSP is!

Continuous integration



Use a **container setup**!

- can be reused within a CI pipeline
- reproducible between different devs and CI
- easier start for new developers

Azure Pipelines

CI/CD

Use a **CI pipeline**!

- Working in a multi-repo setup with different teams and changes in different repos have a large potential to break your environment
- forcing successful CI runs (including tests) as a requirement for merging reduces the risk!

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Continuous integration and automated tests

Your CI should include:

- building all your targets
- checks for code style (linting)
- testing
  - on real hardware and / or virtual devices
  - use / enhance existing test suites e.g.
    - Compatibility Test Suite (CTS)
    - Vendor Test Suite (VTS)
    - Trade Federation Testing Infrastructure (tradefed/TF)
  - write lots of tests!

Android Virtual Devices (AVD)

Tweak existing configuration to match your hardware device as good as possible!

- faster round-trips in development
- can be integrated with CI (e.g. being used for test runs)
- allow easier switching between versions, API levels, …
- portable, home-office friendly

AVDs **do not** replace the need for testing and developing on real hardware, but they are a great convenience feature!

Thank you!

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Further reading

- https://source.android.com/docs/core/architecture
- https://source.android.com/docs/core/architecture/kernel
- https://developer.android.com/studio/run/emulator
- https://www.gerritcodereview.com/index.html
- https://www.inovex.de/de/blog/aosp-advanced-development-tricks/
- https://www.opersys.com/downloads/cc-slides/android-debug/slides-main-221201.html#/