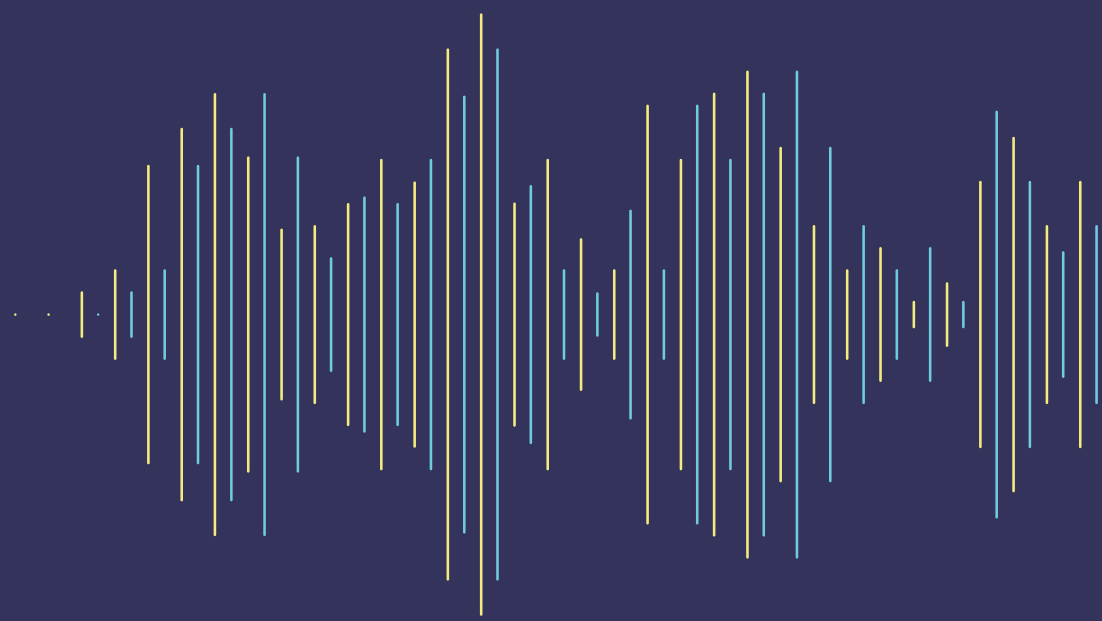


# Sound Open Firmware

**Liam Girdwood**

Open Source Summit + Embedded Linux Conference Europe 2018



**Sound Open Firmware is an open  
source audio digital signal  
processing firmware and driver  
infrastructure.**



# SOF Goals 1

- DSP architecture and platform agnostic.
  - Separate architecture and platform code like Linux\*.
  - Abstract interfaces for architecture APIs (again like Linux).
- Host AP architecture and host AP OS agnostic.
  - Drivers are generic and not coupled to any host architecture.
  - Nothing in SOF that couples firmware or low level driver to any OS.
- Toolchain freedom
  - Fully support open source tools – GCC, Octave, M4, Qemu.
  - Also support proprietary tools - Cadence xcc and emulator, Matlab.
- Permissive licensing of all firmware and most SDK code.

\*Other names and brands may be claimed as the property of others.

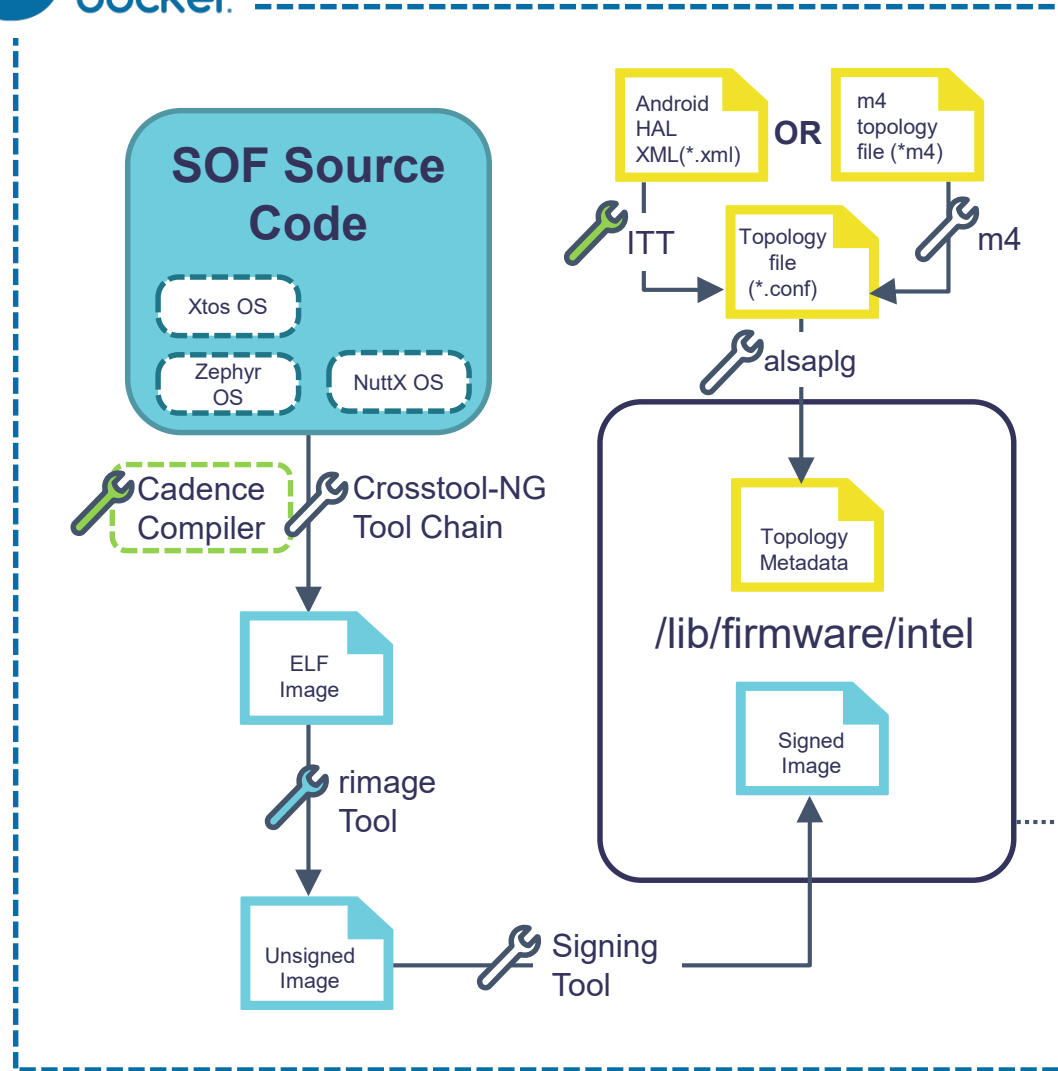


# SOF Goals 2

- Freedom for users to define new audio processing pipelines using open source components and tools.
- Freedom for users to develop and integrate proprietary audio processing algorithms.
- All development done in public.
- Support for several CI systems to best match device and infrastructure under test.



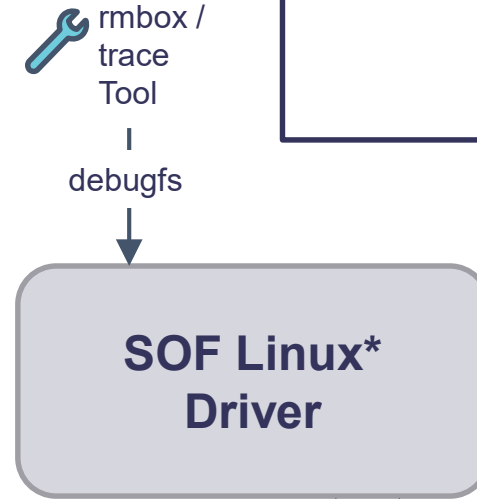
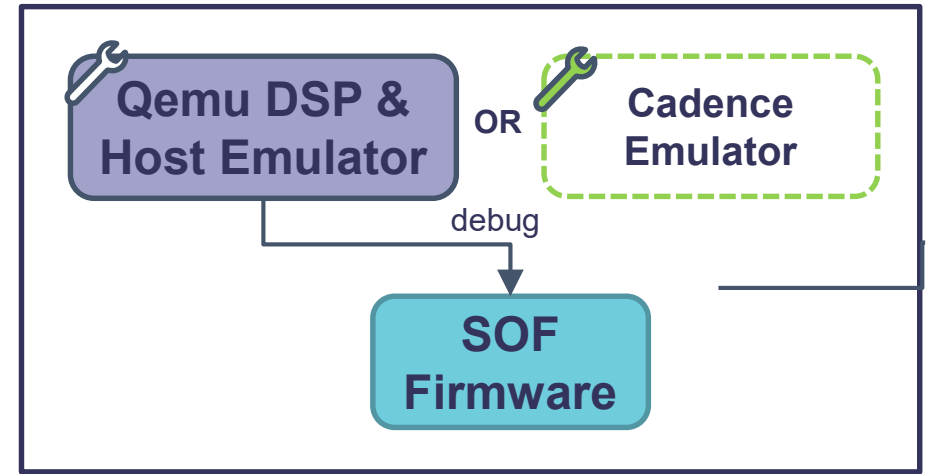
# SDK Birds Eye View 1



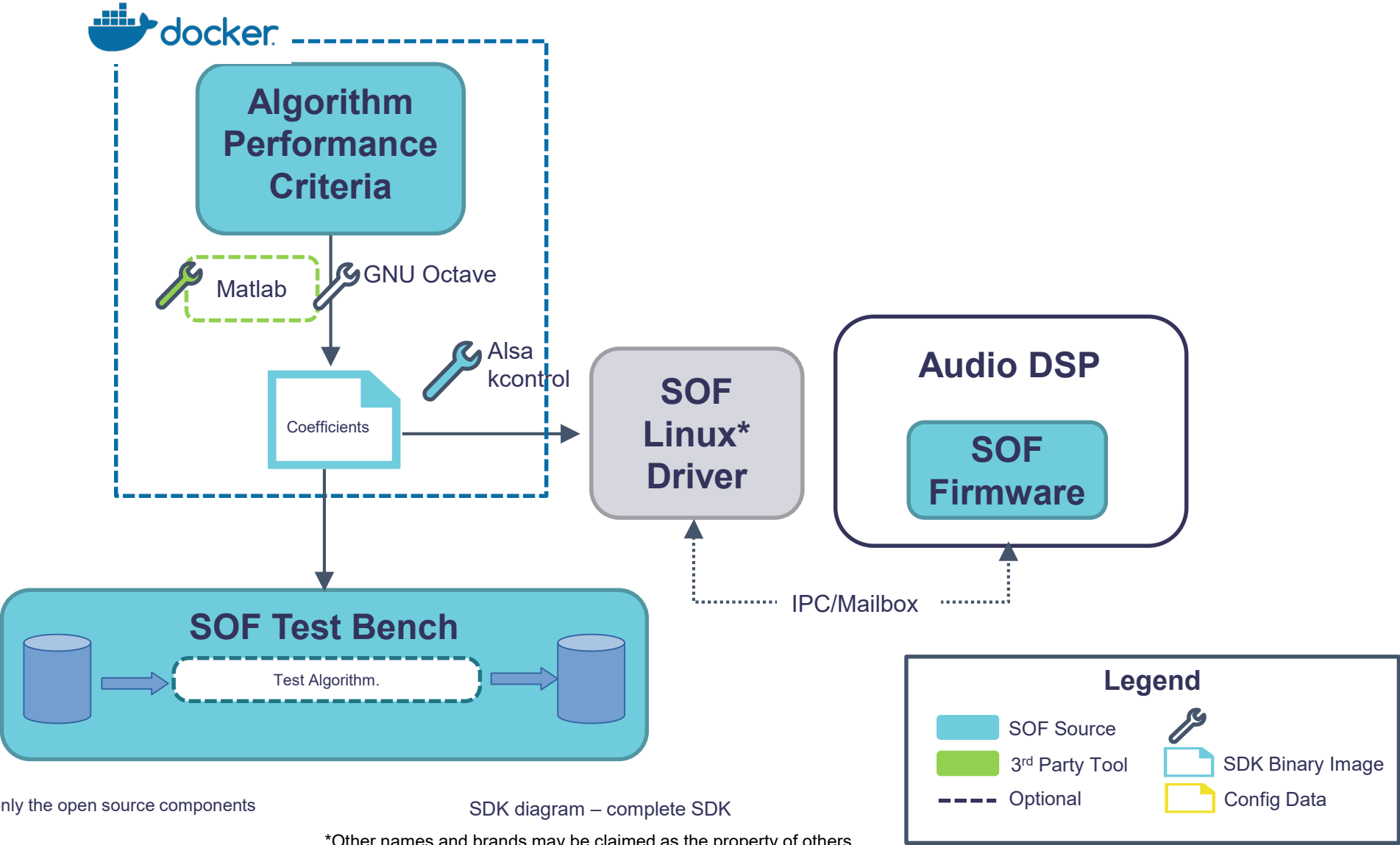
Note: Docker\* contains only the open source components

SDK diagram – complete SDK

\*Other names and brands may be claimed as the property of others.



# SDK Birds Eye View 2



Note: Docker\* contains only the open source components

SDK diagram – complete SDK

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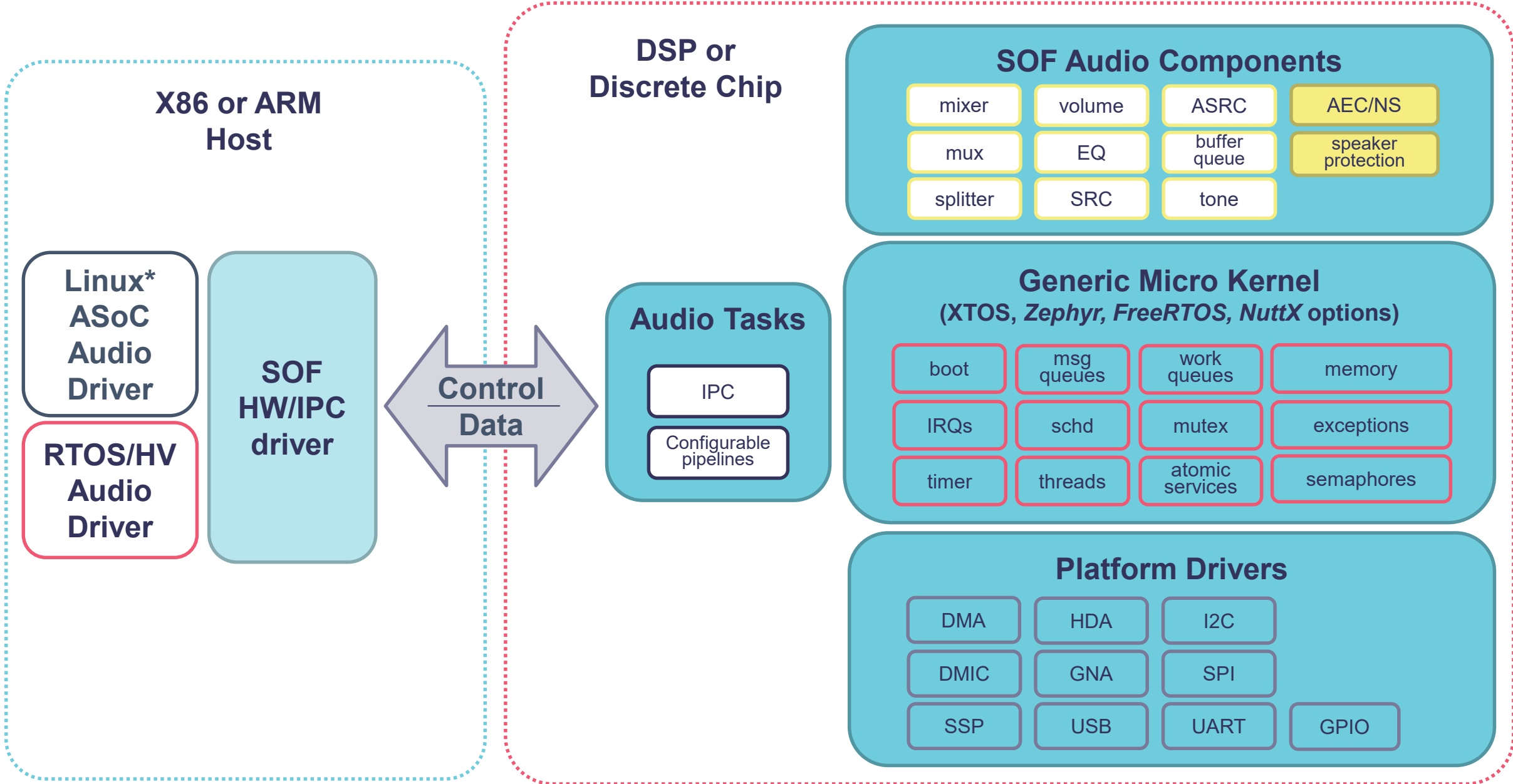


# Firmware Overview

- Architecture agnostic implementation in C with some assembler.
- Permissive BSD/MIT licensed code.
- Build time selection of features based on target (moving to use Kconfig).
- Scales down to ~40kB footprint (text, data and bss).
- Support for user defined audio processing pipeline topologies.
  - Dynamically loaded pipelines at runtime.
  - Statically stitched into image for host less operation.
- Allow general compute and signal processing. Not just an audio FW.
- Image generation tools provided to:
  - Convert ELF to device specific firmware image formats.
  - Sign firmware images with PKCS#1.5



# Firmware Architecture



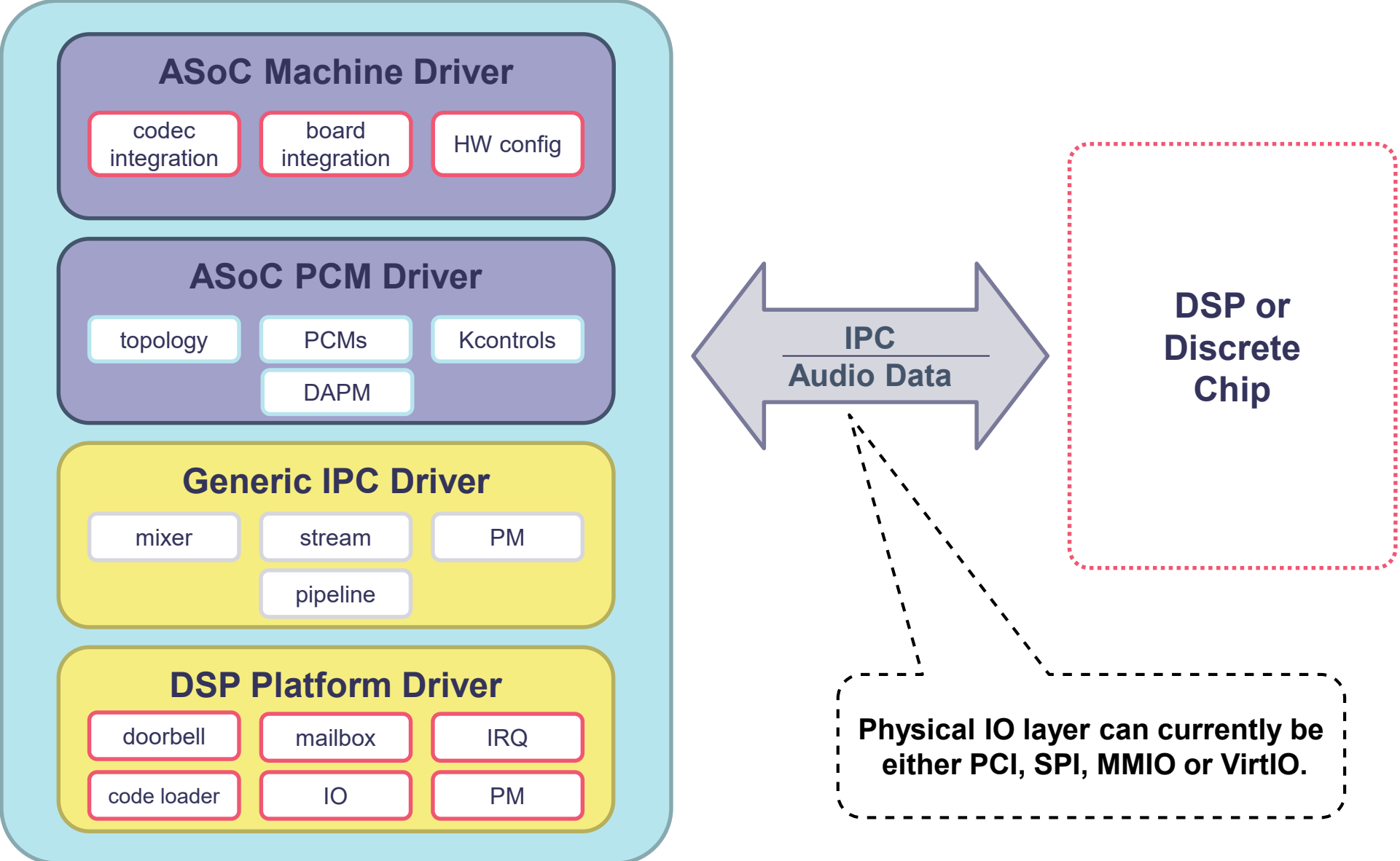
\*Other names and brands may be claimed as the property of others.



# Driver Overview

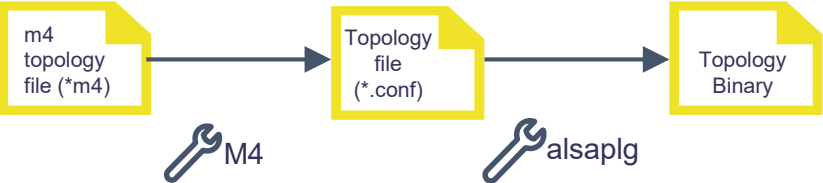
- Architecture agnostic.
- Dual GPL/BSD licensed code.
- Hardware and physical IO abstraction, so can work equally well with local MMIO and remote SPI based DSPs.
- Supports virtualization through VirtIO backend and frontends (using ACRN\*).
- Driver has no hard coded assumptions about DSP pipelines or components.
  - Topologies loaded from FS.
  - Component configurations can be runtime updated via ALSA kcontrols.

# Driver Architecture



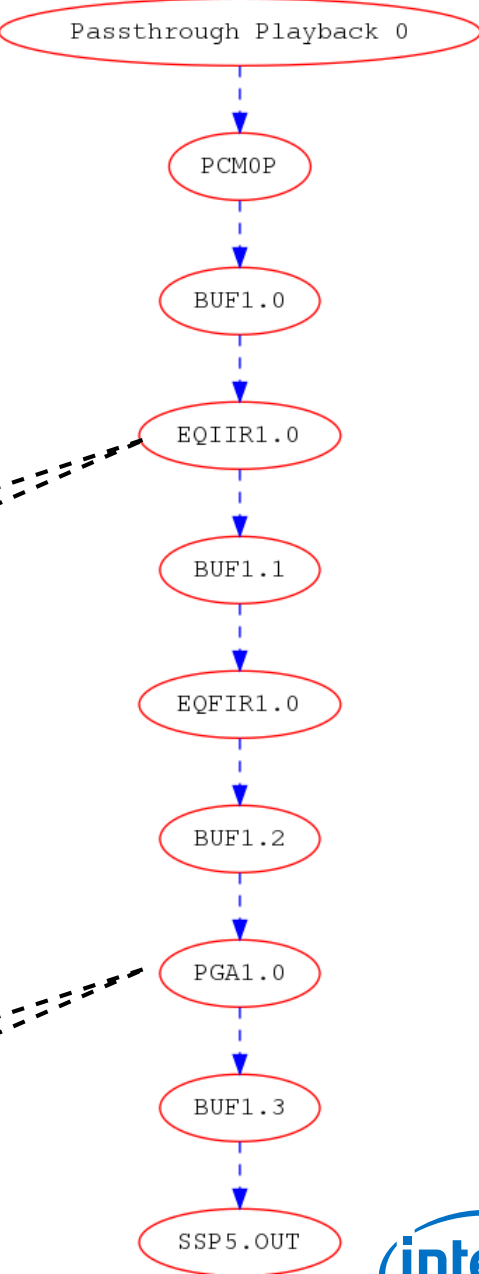
# Pipeline Architecture

- A pipeline is a set of audio processing components and buffers that share common scheduling.
- Pipelines can currently be defined using M4 in a few lines of code. Plans for GUI.



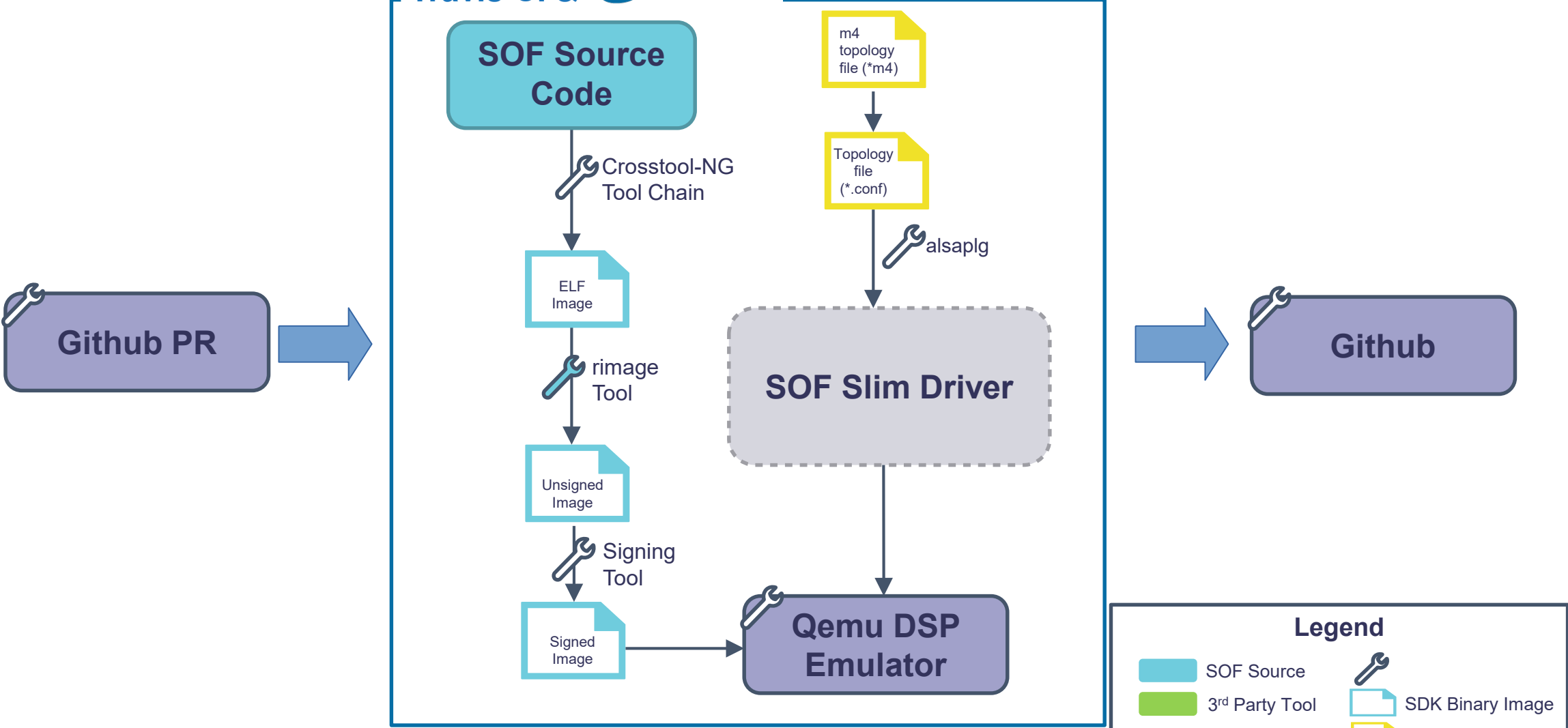
EQ coefficients loaded via ALSA binary kcontrols

Standard ALSA volume kcontrols



# Continuous Integration - Travis

Travis CI &  docker





Note: Docker\* contains only the open source components

SDK diagram – complete SDK

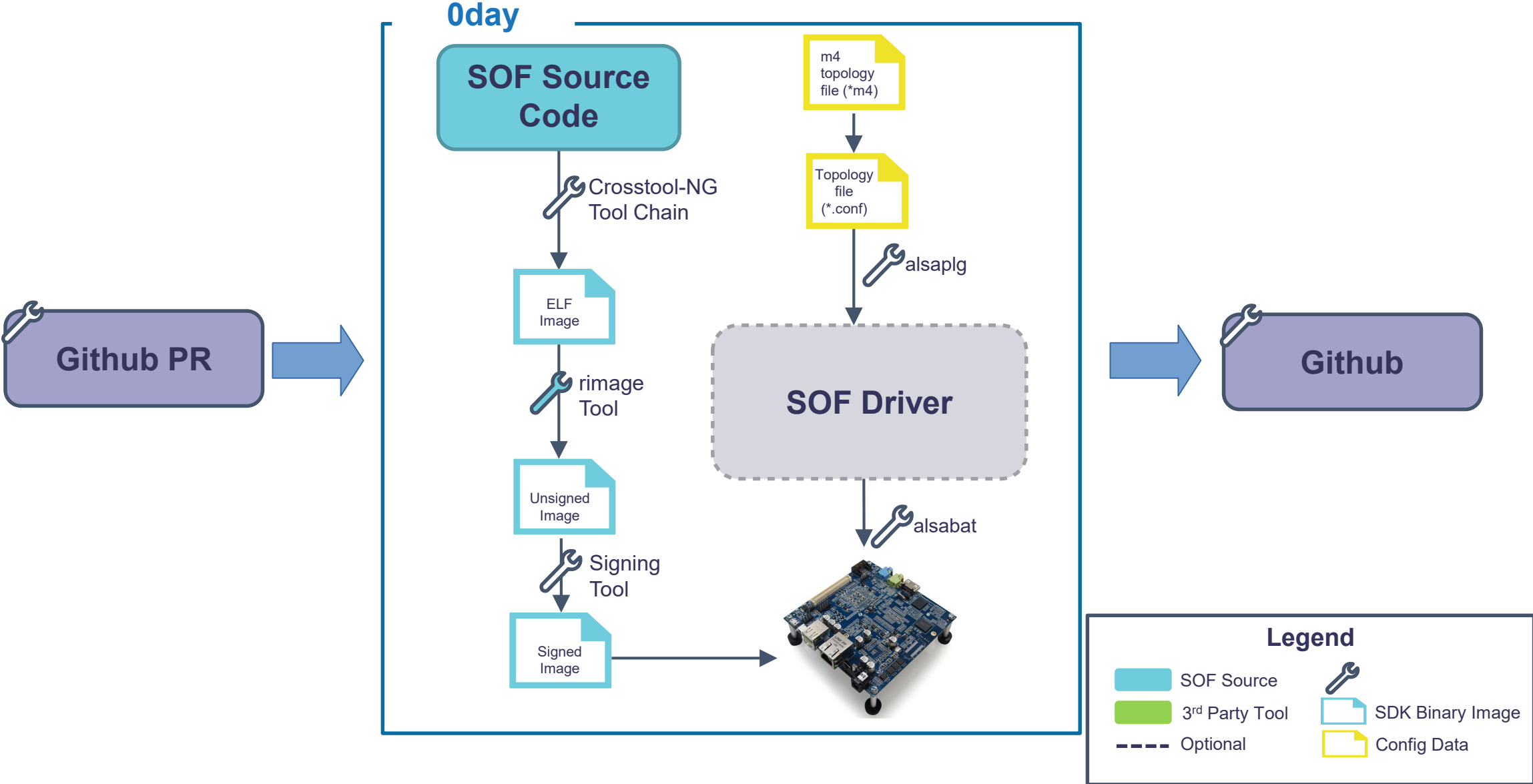
\*Other names and brands may be claimed as the property of others.

**Legend**

- SOF Source
- 3rd Party Tool
- Optional
-  SDK Binary Image
-  Config Data



# Continuous Integration - 0day



SDK diagram – complete SDK



# SOF Platforms

Vendor	Platform	DSP	Status
Generic	Host PC	Host PC	Testbench.
Qemu	Host PC	Qemu targets	Currently only has support for xtensa based devices.
Intel	Baytrail, Cherrytrail, Brasswell	1 * Xtensa HiFi2EP	Upstream, support for upto 6 I2S DAIs.
Intel	Haswell, Broadwell	1 * Xtensa HiFi2EP	Upstream, need I2S integration for some codecs.
Intel	Apollolake, Geminilake	2 * Xtensa HiFi3	Upstream, support for I2S, DMIC, HDMI and HDA.
Intel	Cannonlake, Whiskylake	4 * Xtensa Hifi4	Upstream, support for I2S, DMIC, HDMI and HDA.
Intel	Suecreek HAT on Raspberry PI	2 * Xtensa HiFi4	Upstream core, boot over SPI WiP.
Xiaomi	ARM M4	CEVA Teaklite DSP	Upstreaming WiP.

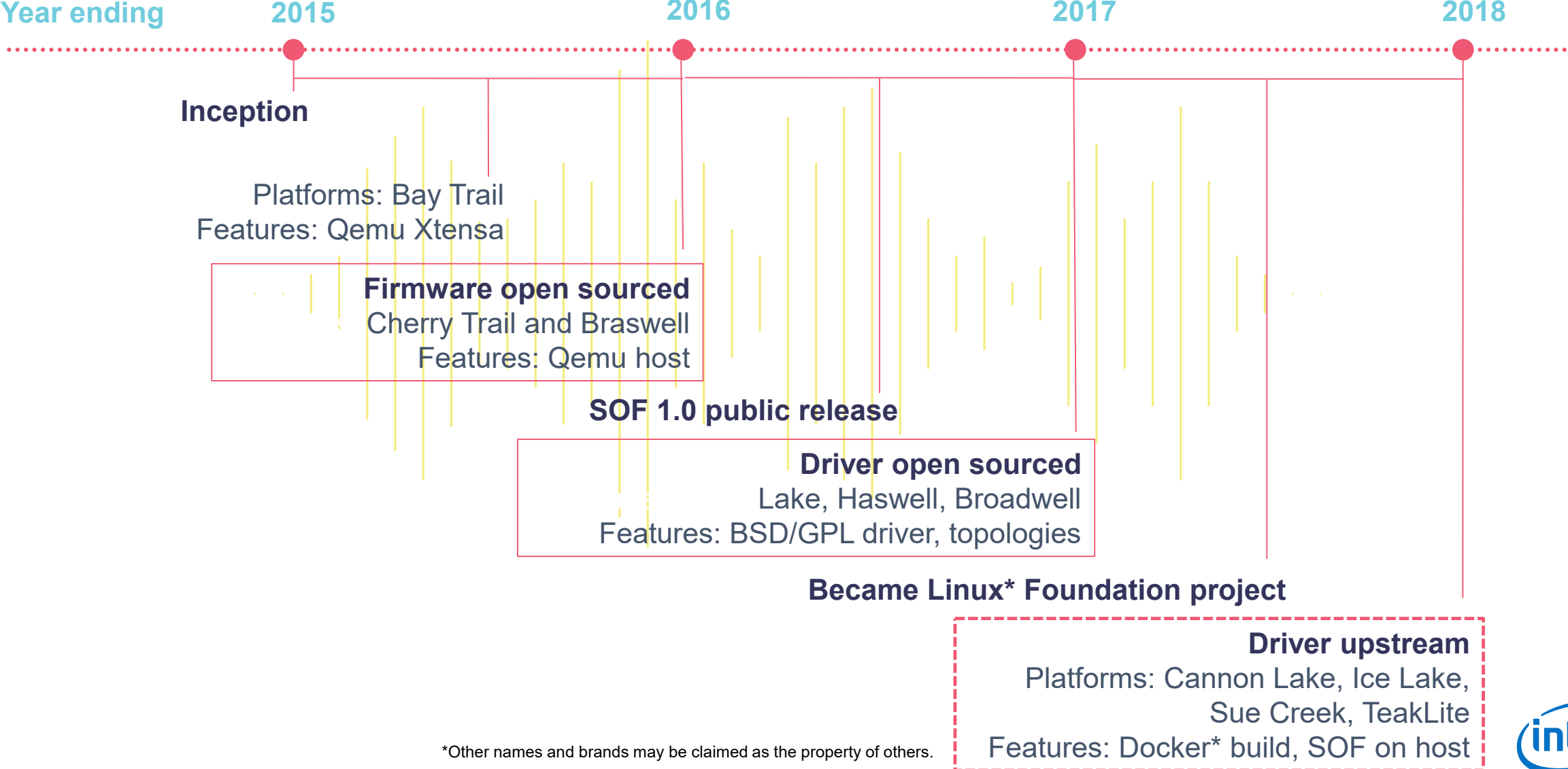


# SOF Processing Components (open source)

Name	Generic C available	SIMD support	Status
Volume	Yes	Xtensa HiFiEP, HiFi3	Upstream, can process 1 – 8 channels, 16, 24 and 32bit formats.
SRC	Yes	Xtensa HiFiEP, HiFi3	Upstream. 24 and 32bit formats. FIR polyphase optimized M/N and M/N x O/P fractional rate conversions.  Configuration tools upstream.
FIR	Yes	Xtensa HiFiEP, HiFi3	16/24/32 bit formats, up to 192 taps.  Configuration tools upstream.
IIR	Yes	Planned	16/24/32 bit formats, up to 11 biquads or 22th order.  Configuration tools upstream.



# History



\*Other names and brands may be claimed as the property of others.





# SOF Future Plans

Feature	Status
GDB stub and tunnel.	Initial firmware and kernel code in developer repository. Upstream in 2019.
RPMSG	Code complete, now upstreaming to SOF and Linux.*
Loadable firmware modules	Initial code in github, still WiP. Upstream in 2019.
CMSIS RTOS Abstraction layer	Work in progress.

\*Other names and brands may be claimed as the property of others.



# Supporting Organizations



pinecone



Xiaomi

\*Other names and brands may be claimed as the property of others.



# Firmware Preference

- Linux\* already has a preference for open source drivers over closed source drivers.
- Should this preference also be extended to open source firmware in the future?
- Selection criteria would also have to consider:
  - Features.
  - Stability.
  - Portability.
- Some open source firmware could still contain binary blobs.
  - Regulatory reasons (e.g. comply with FCC regulations).
  - 3rd party IP (e.g. some audio processing algorithms).

\*Other names and brands may be claimed as the property of others.



# Q & A

[www.sofproject.com](http://www.sofproject.com)

<https://github.com/thesofproject>

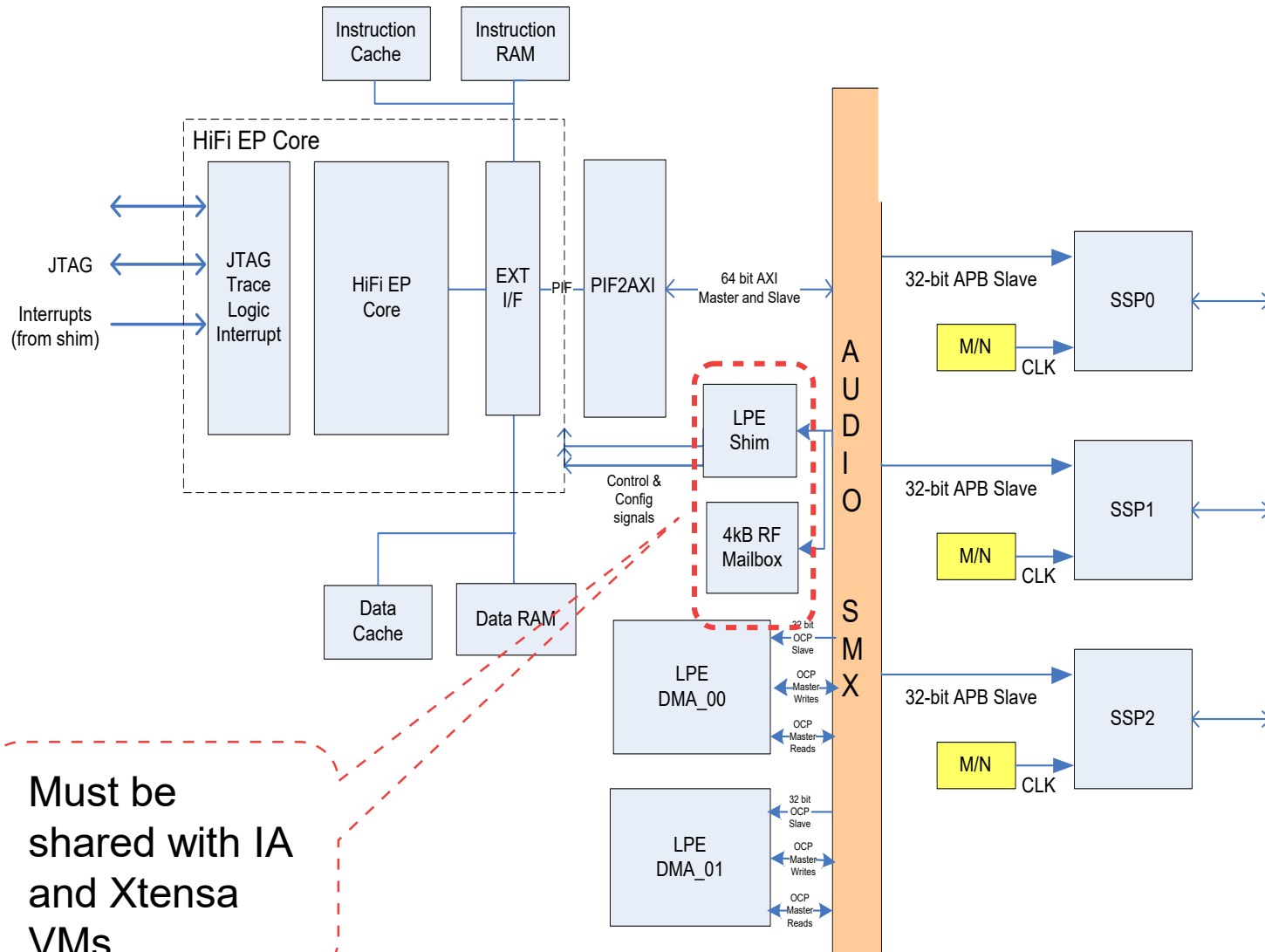
Visit the booth for demo.



# Qemu Heterogeneous Virtualization

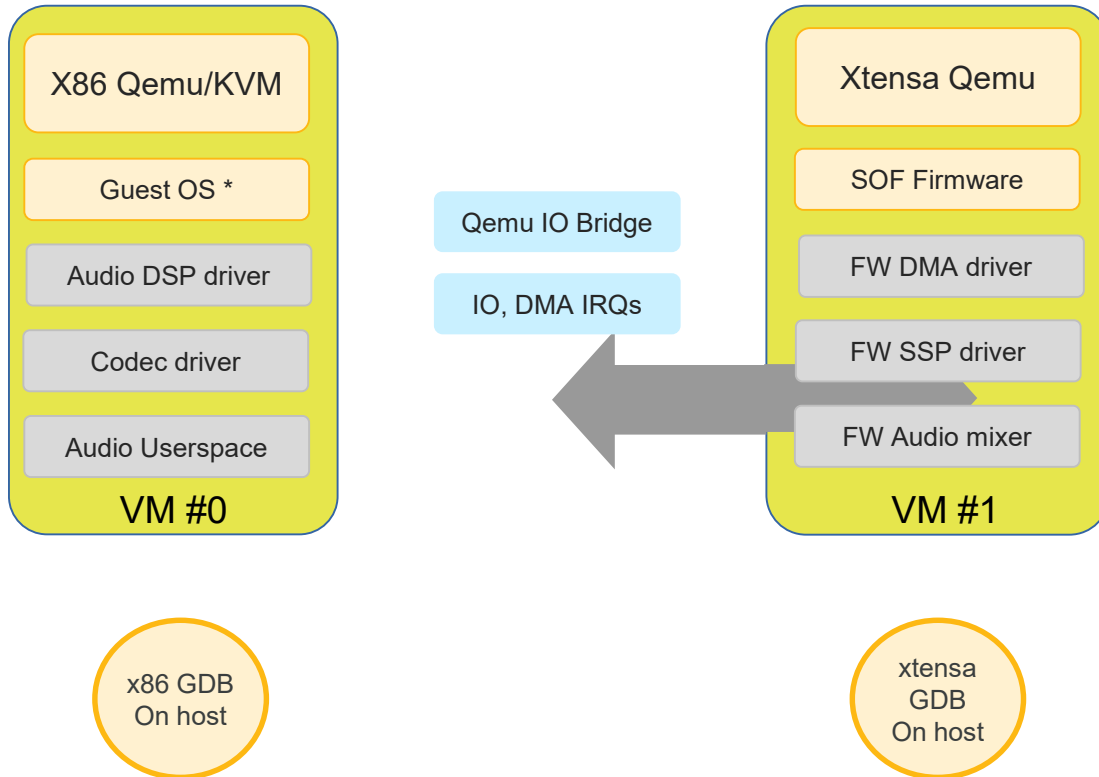


# Baytrail DSP Architecture



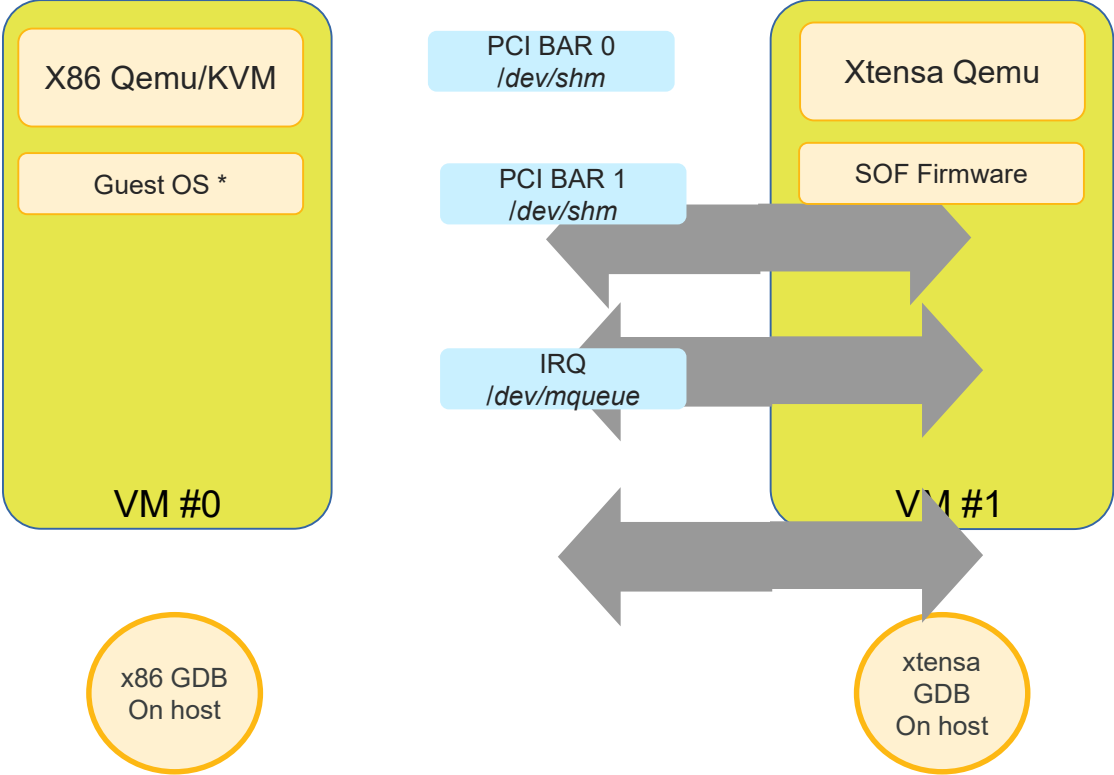
- Xtensa HiFi 2EP core
- 96kB Instruction RAM
- 168kB Data RAM
- 2 \* DMACs
- 3 \* I2S ports
- PCI device from host OS
- Firmware and host share
  - SHIM registers
  - Mailbox memory

# Heterogeneous Virtualization



- Firmware must be debugged alongside driver.
- Qemu used to virtualize drivers and firmware together.
- Host side almost real time.
- DSP side emulated.

# Heterogeneous IO bridging



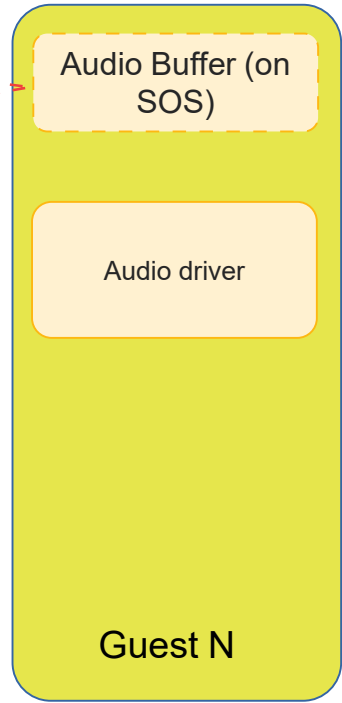


# Zero Copy Virtual Audio



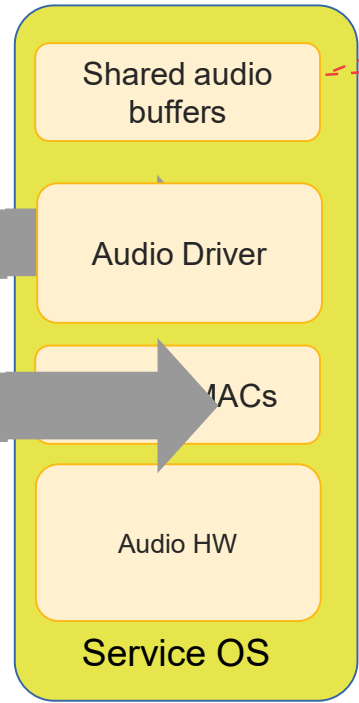
# Zero Copy Audio Virtualization

SOS buffer PHY pages shared with guests.



SOS buffer SG PHY pages

IPC virtio Qs



SOS allocates SG PHY pages for guest audio buffers. Audio DMA copies directly from/to these buffers.



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