# Qualcomm Linux Software System Architecture

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# 1 Qualcomm Linux software system architecture

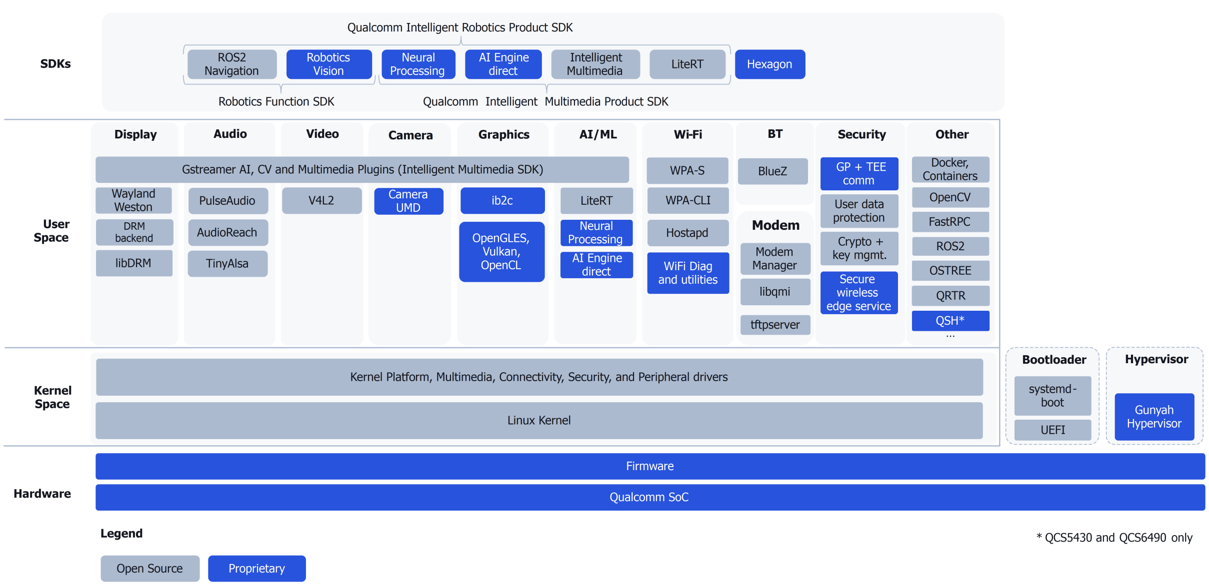
Qualcomm® Linux is a package of software and tools designed for IoT platforms for Qualcomm and has the following versions available for application development:

- The *Base* version is an upstream, open-source software stack without Qualcomm proprietary software.
- The *Custom* version includes downstream Qualcomm proprietary software with extra SDKs and improved power performance.

The following summarizes key features of the main components of each Qualcomm Linux version:

**Custom**

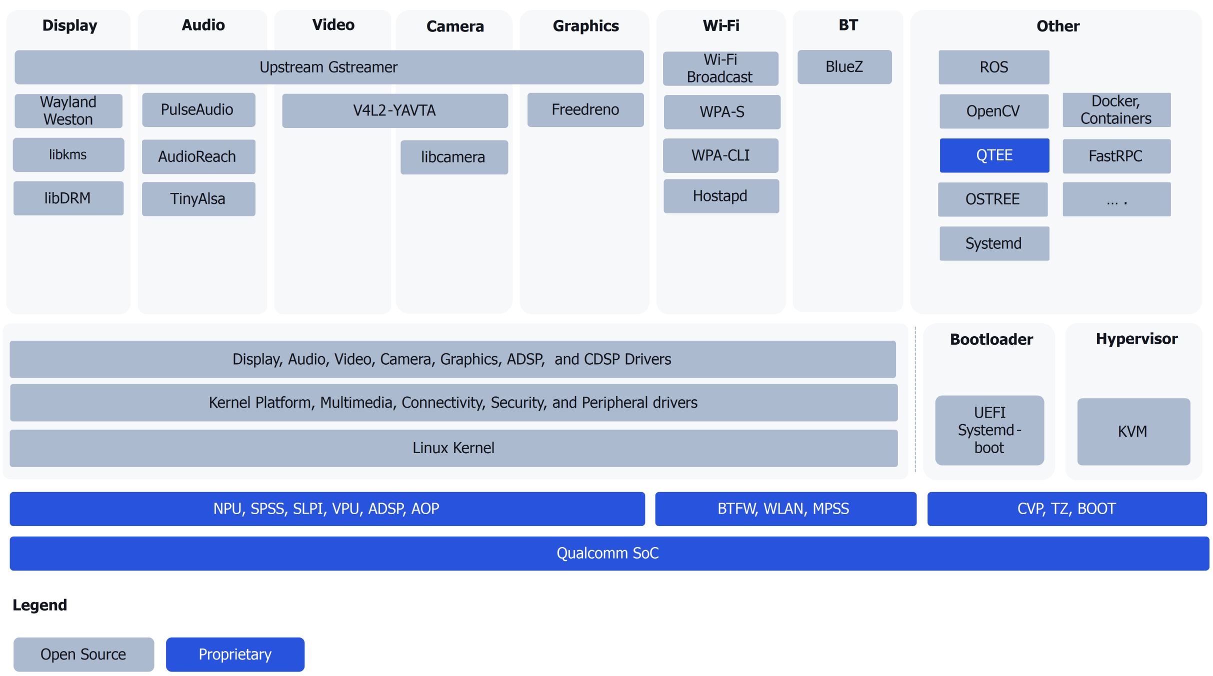
The Custom version of Qualcomm Linux is currently supported on QCS5430, QCS6490, IQ-8275, and IQ-9075 SoC platforms.



**Base**

The Base version of Qualcomm Linux is constructed using upstream components for the entire software stack. It includes a UEFI bootloader and the latest Linux LTS kernel (including a few patches that are in process of upstream). Being fully upstream means that this version *does not* support Qualcomm value adds that are still downstream/proprietary.

The Base version of Qualcomm Linux is currently supported on IQ-8275, IQ-9075, and IQ-615 SoC platforms. A summary of the Qualcomm Linux software environment for IQ-8275 and IQ-9075 is shown in the following figure. For IQ-615 ,see QCS615.LE.1.0 Software User Guide.

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**Note:** The Base version is not fully enabled on this release. The descriptions in the following sections are for informational purposes only. Please see the Release Notes for a complete list of software components enabled in the Base version.

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# 1.1 Display

**Custom**

The display subsystem supports the QIM SDK, which is based on the GStreamer framework and the Wayland protocol. These open-source frameworks provide libraries, APIs, and plug-ins to abstract low-level interfaces. The architecture has the following features:

- The waylandsink plug-in talks to the Weston subsystem to render the display.
- The Weston server is a system-level compositor, which takes care of composition and rendering needs and runs as a separate process in the system.
- libdrm provides APIs for accessing direct rendering manager (DRM) IOCTL.

**Base**

The display subsystem supports upstream Wayland/Weston based framework. The direct rendering manager (DRM) backend is the native Weston backend for systems that support the Linux kernel DRM, kernel mode setting (KMS), and evdev input devices. Developers can use upstream wayland/Weston based applications to validate and enable display use cases.

For more details see the following:

- https://wayland.pages.freedesktop.org/weston/
- https://docs.kernel.org/driver-api/index.html
- https://docs.kernel.org/gpu/drm-uapi.html

**User space components**

GBM

Weston

**Kernel drivers**

Display drivers

## 1.2 Audio

**Custom**

The audio subsystem allows a user-space application to capture audio and request playback. It is ALSA-compliant and supports the GStreamer multimedia framework. It also provides an alternate implementation that does not use GST.

It uses PulseAudio as the sound server. A GST application can open up a pulsesink and a pulsesrc element to render or capture the audio respectively. Further, the captured audio can be rendered out to a ROS2 node for additional processing.

The software audio architecture is Qualcomm's AudioReach™ Signal Processing Framework. AudioReach comprises the signal processing framework (SPF), the audio processing manager (APM), and the Qualcomm audio calibration tool (QACT) for audio system design and calibration. It is a complete package of software components, development kits, and tools to design, implement, and validate end-to-end audio use cases across multiple platforms.

The audio DSP (aDSP) is the DSP component responsible for capture and playback. There is a compute DSP (CDSP) component available that can be used for compute applications in general and leveraged for specific audio use cases like keyword detection based on the framework support.

**Base**

The audio subsystem allows a user-space application to capture audio and request playback. It is PulseAudio based and supports the GStreamer multimedia framework.

A GST application can be developed to render or capture the audio respectively. Further, the captured audio can be rendered out for additional processing.

The audio DSP (aDSP) is the DSP component responsible for capture and playback. There is a compute DSP (CDSP) component available that can be used for compute applications in general and leveraged for specific audio use cases."

Audio PAL

Pulse Audio

Audio device tree

Audio kernel

## 1.3 Video

**Custom**

The video subsystem supports the GStreamer multimedia framework and various video codecs to take full advantage of the VPU for high-quality, ultra HD video encode and decode. The hardware capabilities of the VPU are most effectively exposed through the QIM SDK and V4L2 APIs. The video encoding and decoding in Qualcomm-based SDKs is completely offloaded to video engines enabling the CPU/GPU to be free for other operations.

**Base**

The video subsystem in the Base version supports video functionality though upstream v4l2 interfaces. Developers can use the typical v4l2 based interfaces to playback video in the Base version. For more details on interfaces and sequence flow, refer to https://www.kernel.org/doc/html/v4.9/media/uapi/v4l/user-func.html and https://www.kernel.org/doc/html/latest/userspace-api/media/v4l/dev-mem2mem.html.

For sample V4l2 application, refer to https://github.com/quic/v4l-video-test-app.

Video kernel driver

## 1.4 Camera

**Custom**

The camera subsystem supports the GStreamer multimedia framework and uses the qmmfsrc plug-in to, among other things, handle the capture of the camera frames. The qmmfsrc plug-in provides various APIs that allow developers to control cameras as needed. The qmmfsrc plug-in transfers camera control to the camera user mode driver (UMD) through qmmf-server (camera daemon). The camera UMD is responsible for controlling the overall camera subsystem, including configuring the camera pipeline according to use cases. It also provides an interface to add camera drivers or customize the camera pipeline. The camera kernel mode driver (KMD) is a collection of Linux kernel drivers for the camera subsystem and is responsible for programming the hardware by taking control from the camera UMD.

Camera device tree

Camera kernel driver

**Base**

The camera subsystem in the Base Linux build supports V4L2 interface camera ISP driver for raw frame capture. It supports camera sensors using the V4L2 subdev interface, allowing developers to implement or use V4L2 based camera applications such as yavta and libcamera.

## 1.5 Graphics

**Custom**

The graphics subsystem supports the GStreamer multimedia framework and uses the GStreamer Wayland plug-in. The GPU uses an OpenGL ES based ib2C library to provide hardware-accelerated image manipulation, transformation, and color conversion operations. Other features include:

- OpenGL ES – API for developing 2D and 3D graphics on embedded systems. A subset of the OpenGL API.
- OpenCL – Open standard for cross-platform parallel programming in heterogeneous systems.
- EGL –Interface between Khronos rendering APIs like OpenGL ES and the underlying native platform window system.
- Vulkan – Low-level API and open standard for 3D graphics and computing. Qualcomm Linux supports RGB, UBWC, YUV, and Bayer graphic formats.

**Base**

The graphics subsystem in the Base Linux build is based on upstream graphics stack and only functional GLES support would be enabled.

## 1.6 AI/ML

**Custom**

The Qualcomm AI/ML subsystem supports SDKs, APIs, development tools, and third-party frameworks and models, including GStreamer and TFLite, to provide access to QTI-specific hardware and software capabilities for AI and machine learning. The Qualcomm Neural Processing Engine provides unified APIs and modular/extensible per-accelerator libraries that form a reusable basis for full-stack AI solutions that are usable with Qualcomm's own frameworks as well as open-source frameworks. With the machine learning plug-ins in the framework, developers can use TFLite and the Qualcomm Neural Processing Engine for inferencing. For each of the engines, delegates are enabled to accelerate model inference performance.

The subsystem supports multiple video analytics use cases including:

- Single stream inference with live camera
- Single stream inference on offline video
- Single stream live camera TensorFlow Lite inference streamed over RTSP
- Single stream live camera preview with DirectNN inferencing
- Two stream inference with live camera

**Base**

## 1.7 Qualcomm sensing hub (QSH)

**Custom**

The Qualcomm sensing hub (QSH) supports hardware and software sensors like accelerometer, gyroscope, and pedometer. It offers a unified event-driven framework for drivers and algorithms. It supports the same set of APIs for both the hardware-based and software-based sensors.

QSH is currently supported on QCS5430 and QCS6490. It's not enabled on IQ-8275 and IQ-9075 processors.

**Base**

## 1.8 Wi-Fi

Qualcomm Linux provides Wi-Fi functionality, features, and configurable parameters for developing applications. In Qualcomm Linux, Wi-Fi functionality is enabled through the ath11k driver along with chipset specific firmware.

The following features are supported:

- 2.4 GHz, 5 GHz, and 6 GHz Wi-Fi bands
- Peak PHY data rate of 2.9 Gbps, 1 K QAM
- Station (STA) mode and Access Point (AP) mode

See Qualcomm Linux Wi-Fi Guide for more details.

## 1.9 Bluetooth

The Bluetooth® wireless technology is a short-range communications system that facilitates wireless exchange of data between devices. Qualcomm Linux Bluetooth solution includes BlueZ stack and sample test applications for different user cases.

Supported software and chipsets provide the following two modes of operations:

- Basic Rate/Enhanced Data Rate (BR/EDR)
- Blue tooth Low Energy (BLE)

Qualcomm Connectivity chipsets (WCN) comply with the Bluetooth Core specification v5.2. See Qualcomm Linux Bluetooth for more details.

## 1.10 Security

The Qualcomm Trusted Execution Environment (TEE) in the security subsystem provides security services, such as image loading, authentication, cache management, crypto, logging, and Qualcomm fuse-programmable read-only memory (QFPROM) to TrustZone (TZ) secure applications.

TZ is the core of product security on Qualcomm's platforms, and it facilitates a secure execution environment for most of the product security features. TZ is built on Arm core TZ technology and relies on the secure execution mode of the Arm core.

The product security feature set comprises the following security components:

- TZ and secure application

- Qualcomm TEE 5.3
- Secure boot and QFPROM
- HLOS security
- Secure storage
- Secure device debugging
- Secure boot

## 1.11 Boot

The boot subsystem of Qualcomm Linux supports systemd-boot UEFI boot manager. When the system resets, the bootloader in the application processor executes in secure ROM and initializes clocks, CPU caches, and the memory management unit (MMU), and then detects the boot device as per the boot option configuration. Boot options include UFS. The remaining system and subsystem images are then loaded and authenticated in ROM, IMEM, and DDR as described in the cold boot flow.

Additional boot features include:

- Secure boot
- Flexible security key architecture (FSKA)
- Configuration data tables (CDT)
- Emergency download (EDL) mode
- Thermal detection to stop device from booting/rebooting in thermal scenarios

## 1.12 Hypervisor

Qualcomm Linux uses Gunyah, a Type 1 hypervisor for strong security, performance, and modularity. Independent of any high-level OS kernel, Gunyah runs in a higher CPU privilege level, and doesn't depend on any lower-privileged OS kernel/code for its core functionality. This increases its security and can support a much smaller trusted computing base than a Type 2 hypervisor.

Gunyah is designed to support multiple CPU architectures, so its core design ensures architecture independence and portability in non-architecture specific areas. Qualcomm Linux includes the setup tools and scripts, Gunyah core, resource manager, and C runtime environment for the resource manager.

## 1.13 Kernel Space

Qualcomm Linux is a Linux Embedded offering and includes the long-term support (LTS) Linux kernel with the associated kernel platform, multimedia, connectivity, security, and peripheral drivers. Most drivers are pure upstream or in the process of upstreaming, with a few downstream drivers to enable the necessary hardware features.

Custom kernel

Base kernel

## 1.14 OTA

OTA using the OSTree frameworks is supported from QLI GA 1.3. Customers must program the partition layout to ensure migration from QLI GA 1.3 to QLI GA 1.4 through OTA process.

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