

AM57x Sitara™ Processors

Multimedia and Graphics

Agenda

- Introduction to GStreamer Framework for Multimedia Applications
- AM57x Multimedia and Graphics Functions
 - Hardware Architecture
 - Software Capabilities
- Multimedia Software Architecture
- For More Information

Introduction to GStreamer Framework

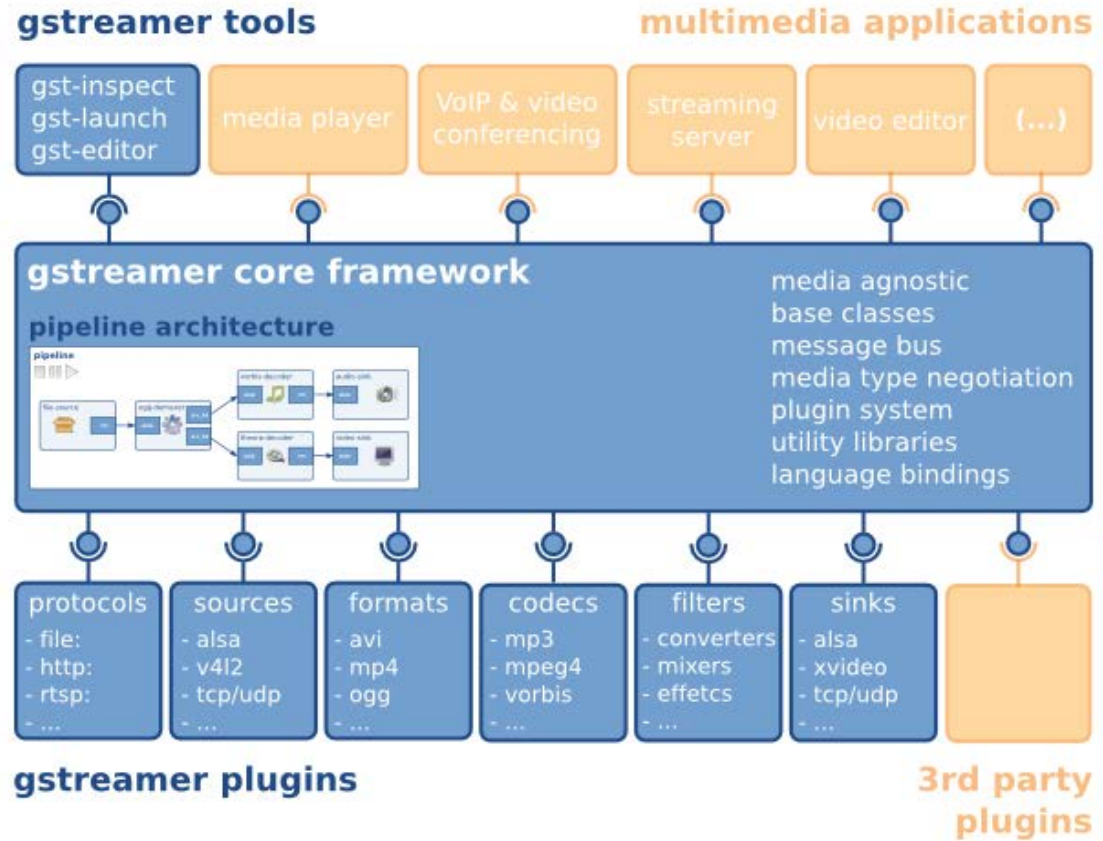
AM57x Sitara™ Processors Multimedia and Graphics

GStreamer Open-source Multimedia Framework

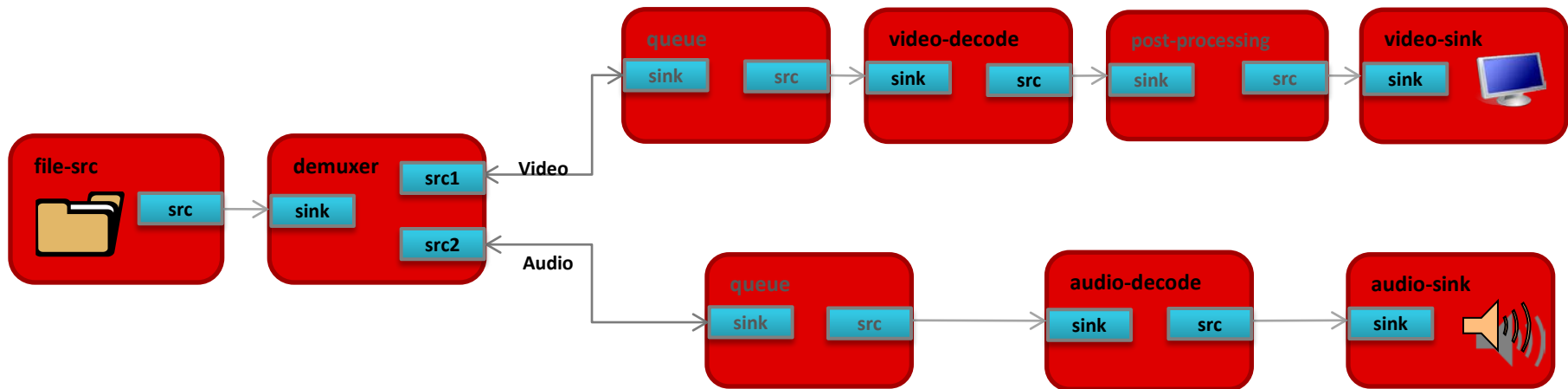
- Multimedia processing library
- Includes parsing & A/V sync support
- Provides uniform framework across platforms
- Modular with flexibility to add new functionality via plugins
- Easy bindings to other frameworks

GStreamer Software Stack

- **Elements:** Sources, filters, sinks
- **Pads:** Element source / sink connection points
- **Caps:** Capabilities organized by stream type with a set of properties
- **Plugin:** Collection of elements
- **Bin:** Container for collection of elements
- **Pipeline:** Top-level bin that allows scheduling and running of all of the elements
- **Bus:** Message interface that allows asynchronous interaction with an active pipeline



GStreamer Pipeline Architecture



- Elements are connected through src/sink pads.
- Data is queued until the maximum specified buffer limit is reached. Element queue will then create a new thread to decouple src/sink processing.
- Post-processing elements, such as color conversion to support various display panels, may be required.
- Parsers can be used to cut streams into buffers. They do not modify the data otherwise.

GStreamer: Installed Programs

- **gst-inspect-1.0** prints information about a GStreamer plugin or element.
- **gst-launch-1.0** is a tool that builds and runs basic GStreamer pipelines.
- **gst-feedback-1.0** generates debug info for GStreamer bug reports.
- **gst-typefind-1.0** uses the GStreamer type finding system to determine the relevant GStreamer plugin to parse or decode a file.
- **gst-xmlinspect-1.0** prints information about a GStreamer plugin or element in XML document format.
- **gst-xmllaunch-1.0** is used to build and run a basic GStreamer pipeline, loading it from an XML description.

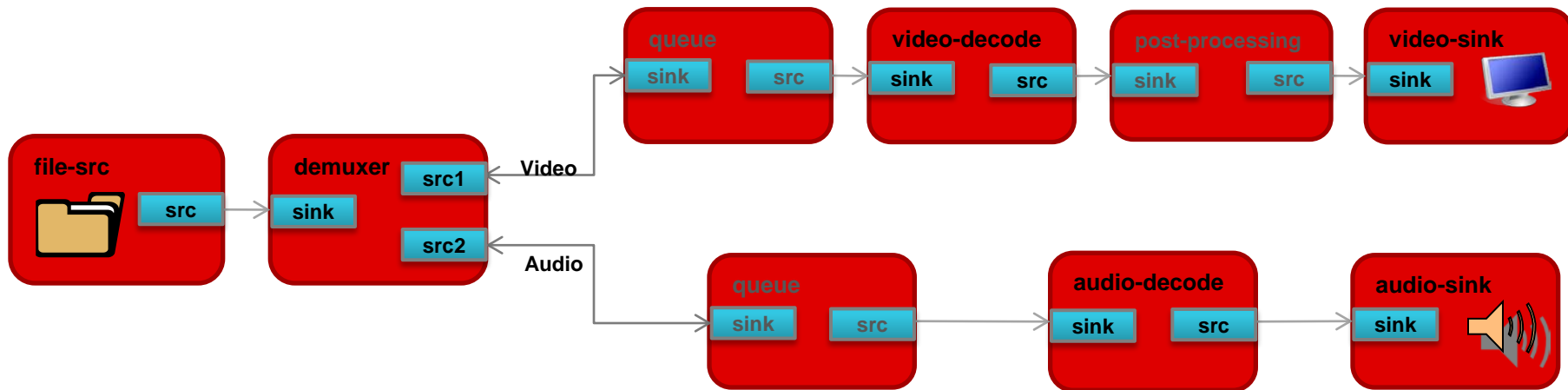
Debugging

- **--gst-debug-help** prints available debug categories and exit.
- **--gst-debug-level=LEVEL** sets the default debug level, which can range from 0 (no output) to 9 (everything).
- **--gst-debug=LIST** takes a comma-separated list of category_name:level pairs to set specific levels for the individual categories. Example:GST_AUTOPLUG:5,avidemux:3. Alternatively, you can also set the GST_DEBUG environment variable, which has the same effect.
- **--gst-debug-no-color** disables color debugging. You can also set the GST_DEBUG_NO_COLOR environment variable to 1 if you want to disable colored debug output permanently.

NOTE: If you are disabling color purely to avoid messing up your pager output, try using **less -R**.

- **--gst-debug-disable** disables debugging altogether.
- **--gst-plugin-spew** enables printout of errors while loading GStreamer plugins.

GStreamer Pipeline Instruction



```
gst-launch-1.0 filesrc location=<source file> ! <demux> demux.video_0 ! queue !  
<video decode> ! <posr-processing> ! video-sink demux.audio_0 ! queue ! <audio-  
decode> ! <audio-sink>
```

AM57x Multimedia and Graphics Functions

AM57x Sitara™ Processors Multimedia and Graphics

AM572x Cortex[®]-A15 based Processors

Benefits

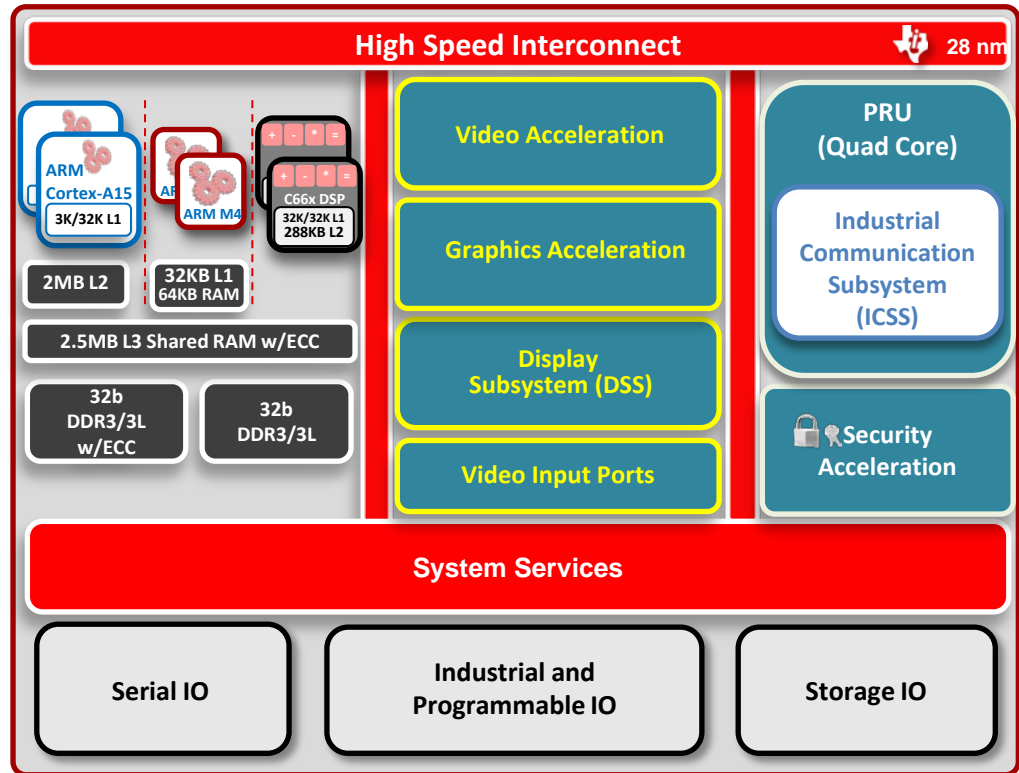
- Sitara's highest performance ARM device w/DSP accelerators
- 10,500 ARM Cortex-A15 DMIPS
- Upgraded graphics performance with HD Video support

Sample Applications

- Human Machine Interface (HMI)
- Industrial PC
- Digital Signage
- High-end Navigation and Consumer

Key Features

- Dual 1.5GHz* Cortex-A15s, 213MHz M4s, and 750MHz** C66x DSPs
- **1080p video decode/encode**
- **3D (x2) and 2D graphics acceleration**
- **Display Subsystem (DSS)**
- **Multiple video input ports**
- Quad core Programmable Real-time Unit (PRU)/Industrial Communications Subsystem (2x dual core subsystem)
- USB3, PCIe, SATA



Video Codec Accelerator (IVA-HD)

AM57x Multimedia and Graphics Functions

IVA-HD

- IVA (Image and Video Accelerator) HD-based video processing solution
 - Single core on both AM572x and AM571x
- Supported Codecs:
 - Video Decode: H264, MPEG4, MPEG2, and VC1
 - Video Encode: H264 and MPEG4
 - Image Decode: JPEG

H.264 Decoder Feature Summary

- All features of main and high profile:
 - Progressive, interlaced, Picture Adaptive Frame Field
 - CAVLC and CABAC
 - Multiple slices
 - Multiple reference frames
 - Error concealment
 - Dynamic resolution change
 - Stream format : Byte Stream, NAL Unit
 - Up to 16MV per MB
 - Tested for compliance with JM version 10.1 reference decoder
- Easy integration with multimedia frameworks
- Graceful exit and error reporting under error conditions
- Optimized for DDR bandwidth, HDVICP MHz, and power
- xDAIS/xDM API compliant
- 1080p60

H.264 Encoder Feature Summary

- Supports H.264 baseline, high, and main profile up to Level 5.1
- Resolutions from 96x80 to 4352x4096
 - In Processor SDK, only up to 1080p resolution is supported.
- True “Full entitlement” encoding: User-control for all H.264 intra-modes and inter-modes
- Superlative video quality surpassing industry-standard encoders
 - 10+ proprietary patented algorithms, including scene analysis, mode detection, motion estimation, and rate control
- Video analytics support with motion vector and cost sharing
- Motion estimation scheme highly optimized to DDR bandwidth
- Patented high-range motion search capabilities
- Advanced rate control options
- Interlaced coding with field-mode scaling matrices support
- Supplemental Enhancement Information (SEI)
- Video Usability Information (VUI)
- Optimized for DDR bandwidth, HD-VICP MHz, power, and video quality

ARM Codecs

- Video decoding on ARM: H.265 (up to 720p30)
- Audio encoding and decoding on ARM: AAC, MPEG2 (leveraging open source codecs)

AM57x Multimedia Codecs

Codec	Enc/Dec	Profile(s)	Resolution/Framerate (simultaneous streams)	Container formats	Audio	Notes
H.264	Enc	BP, MP, HP up to level 5.1	1080p30 (1) 720p30 (1) D1-30 (1)			Accelerated
	Dec	BP, MP, HP up to level 5.1	1080p60 (1) 1080p30 (1) 720p30 (2) D1 – 30 (4)	MP4, 3GP, TS, AVI	AAC (A15 based)	Accelerated
MPEG4	Enc	SP, levels: 0, 0b, 1, 2, 3, 4A, 5, & 6	1080p30 (1) 720p30 (1) D1-30 (1)			Accelerated
	Dec	SP, levels: 0, 1, 2, 3, 4A, 5, & 6 ASP, levels: 0, 1, 2, 3, 4, 5, & 6	1080p60 (1) 1080p30 (1) 720p30 (2) D1 – 30 (4)	MP4, 3GP, TS, AVI	AAC(A15 based)	Accelerated
H.265	Dec	Main, up to level 5.0	720p30 (1)	--	--	A15 based, AM572x only
MPEG2	Dec	Up to MP high level	1080p60 (1) 1080p30 (2) 720p30 (4) D1-30 (8)	MP4, 3GP, TS, AVI	AAC(A15 based)	Accelerated
JPEG	Dec	Baseline sequential mode	32x32~4096x4096	--	--	Accelerated
VC1	Dec	SP, MP, AP	Up to 1080p60 (1)	AVI, MP4, Matroska		Accelerated

- Up to 1080p60 decode or 1080p30 encode support for MPEG4 and H.264*
- Up to 4 channel decode support at D1 resolution
- Up to 2 channel decode support at 720p30 resolution*
- Single channel encode support (1080p30, D1, and QVGA)*

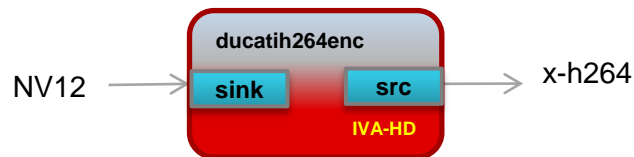
Customer is responsible for all license fees associated with use of these codecs.
Subject to change without notice.

TI Codec GStreamer Plugins

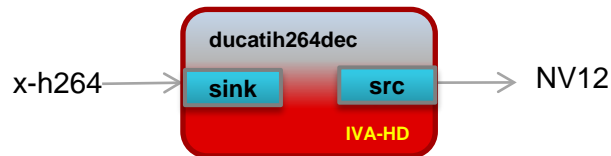
Ducati decoding and encoding:

- ducatih264dec
- ducatimpeg4dec
- ducatimpeg2dec
- ducativc1dec
- ducatijpegdec
- ducatih264enc
- ducatimpeg4enc

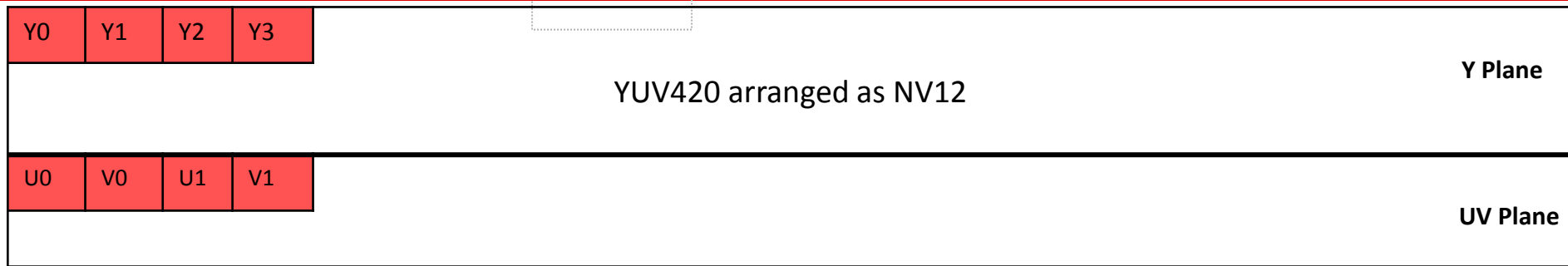
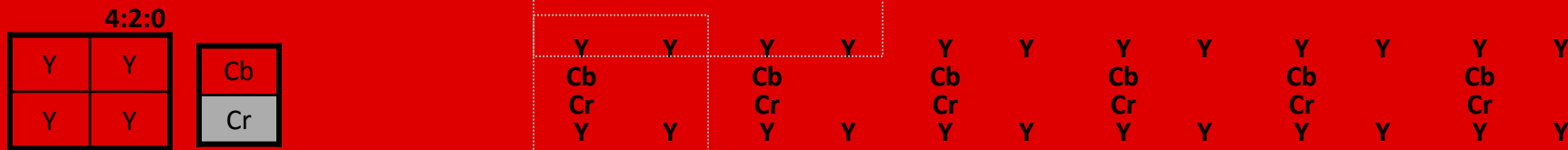
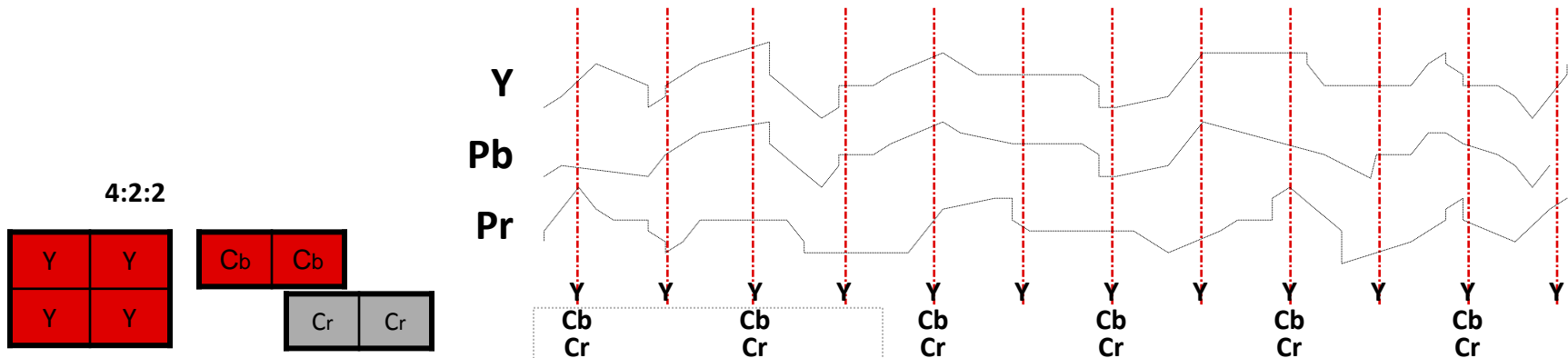
- `gst-inspect-1.0 ducatih264enc`



- `gst-inspect-1.0 ducatih264dec`

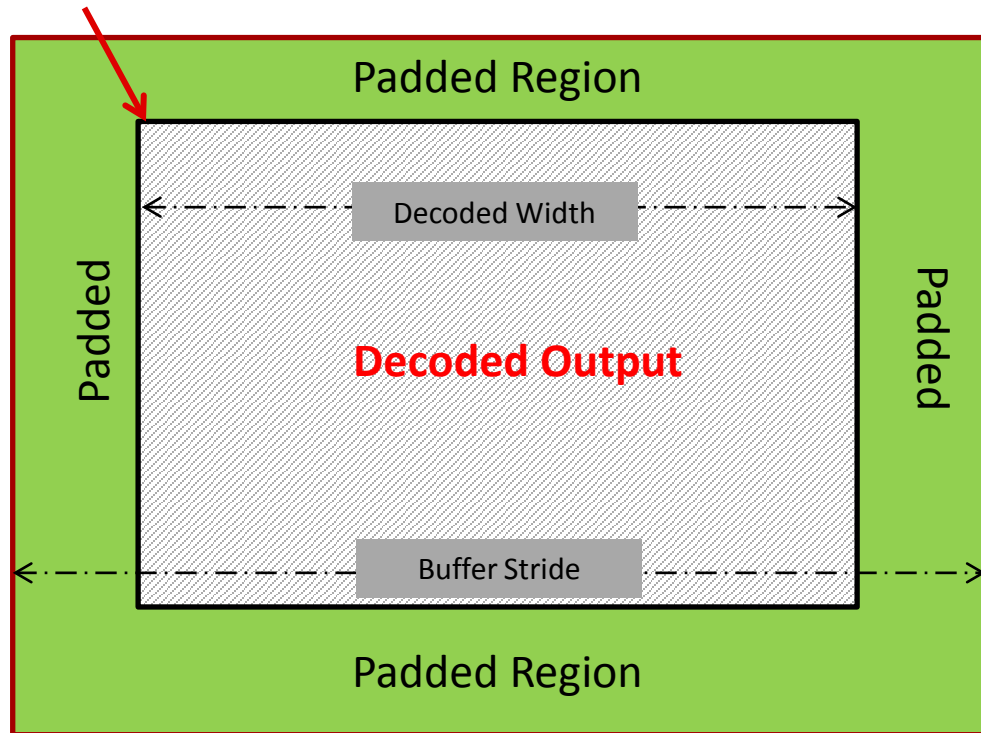


Codec YUV Buffer Format – NV12



Decoder – Output Buffer With Padding Around

Decoded output Start pointer

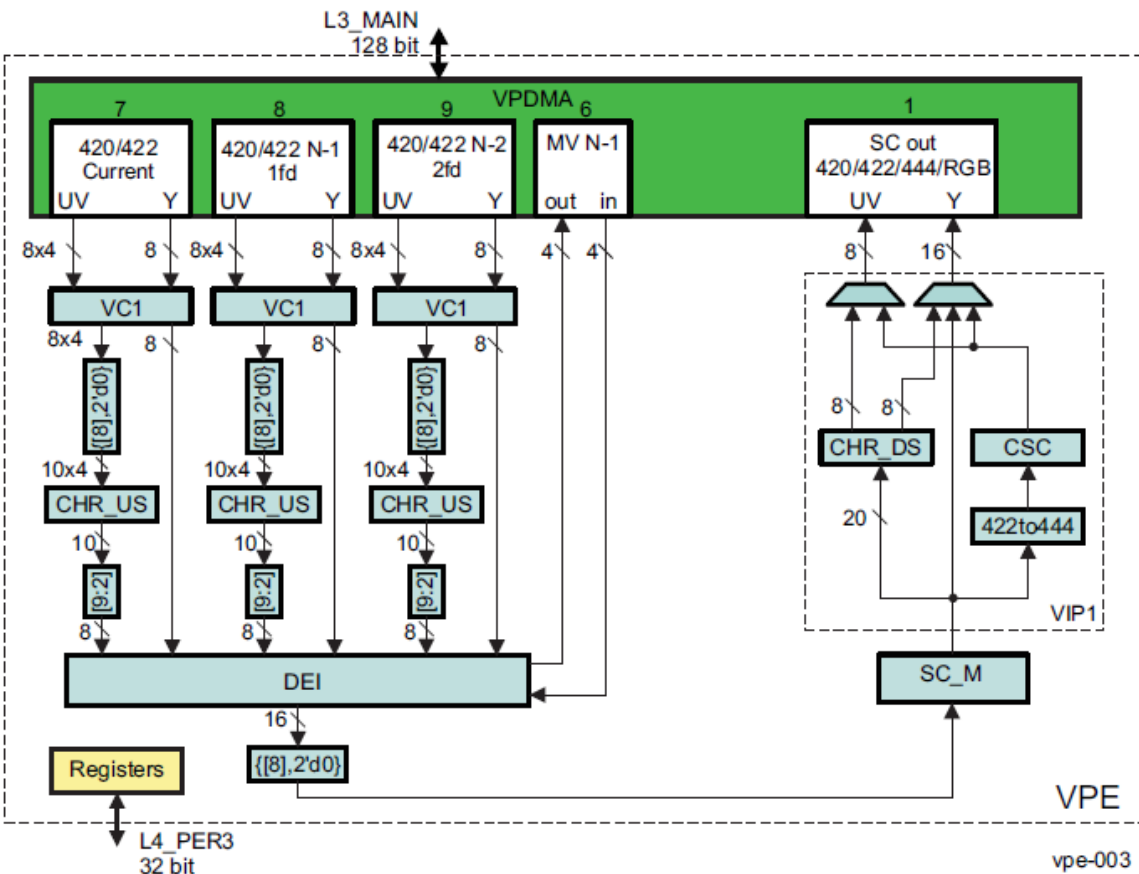


- Decoders share an internal reference buffer to produce the decoded output.
- Reference buffers have metadata around the borders of the decoded output.
- In Processor SDK version 1.x, an application is required to crop the metadata to consume the decoded output.

Video Processing Engine (VPE)

AM57x Multimedia and Graphics Functions

Video Processing Engine (VPE)



Memory-to-memory Video Processing Coprocessor

- **Single stream** processing (1080i/p) at 266MHz
- VC1-remapping
- Chroma Upsampling (420→422)
- **De-interlacing** (interlaced → progressive)
- Minimum horizontal scaling ratio = 1/8x
- Maximum horizontal scaling ratio: only limited by maximum output width (2047 pixels)
- Chroma Downsampling (422→420)
- Color Space Conversion (YUV→ RGB)

VPE Driver

- Features supported:
 - Video operations: scaling, color space conversion, and de-interlacing
 - Input formats: NV12, YUYV, and UYVY
 - Output formats: NV12, YUYV, UYVY, RGB24, BGR24, ARGB24, and ABGR24
 - Inline scaling
 - Horizontal upscaling up to 8x and downscaling up to 4x using pre-decimation filter.
 - Vertical upscaling up to 8x and polyphase downscaling up to 4x followed by RAV scaling.
- Features not supported:
 - Formats: YUV444, YVYU, VYUY, NV16, NV61, NV21, 16bit, and Lower RGB
 - Passing of custom scaler and CSC coefficients through user space
 - Deinterlacer film mode detection
 - VC1 range mapping

VPE Driver-Level Performance Benchmarking

Operation	Time for 1000 frames	Frames per second	Hardware utilization
DEI 1920 540 yuyv to 1920 1080 yuyv 1	7.94 s	125.94	98.17%
SC 1280 720 yuyv to 1920 1080 yuyv 0	7.89 s	126.74	98.80%
CSC 1920 1080 yuyv to 1920 1080 rgb24 0	7.91 s	126.42	98.55%
CSC 320 240 yuyv to 640 480 nv12 0	1.20 s	833.33	96.24%
+ 720 240 nv12 to 1280 720 yuyv 1	3.55 s	281.69	97.59%
SC 720 240 yuyv to 720 480 yuyv 1	1.36 s	735.29	95.53%

*This performance has yet to be benchmarked in Processor SDK software.

GStreamer Plugin for VPE

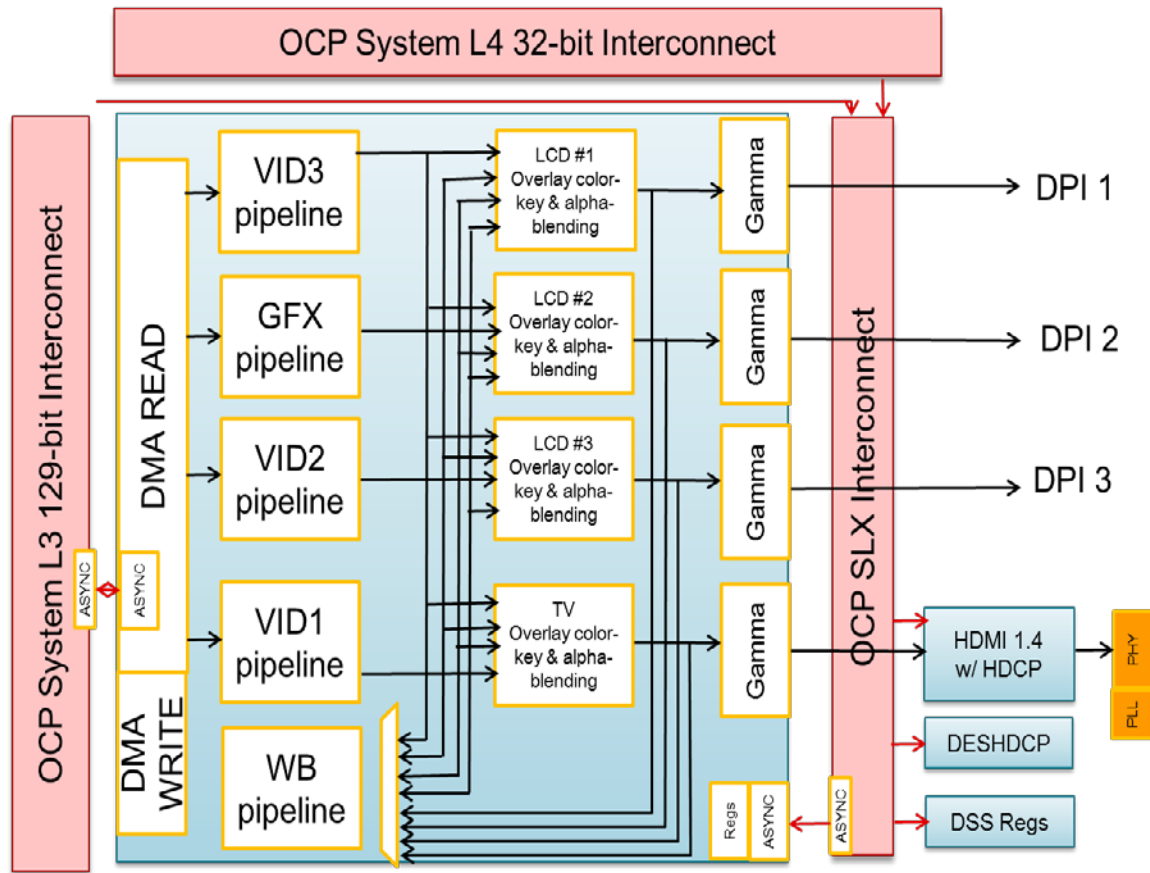
gst-inspect-1.0 vpe



Display Subsystem (DSS)

AM57x Multimedia and Graphics Functions

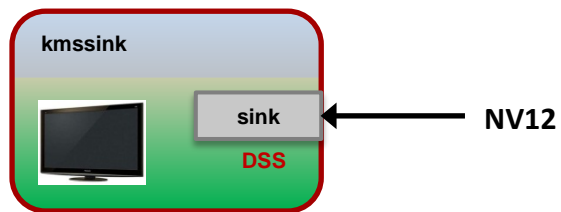
Display Subsystem Block Diagram



- Integrated enhanced DMA engine inside DISPC IP
- Processing capability inside DISPC IP:
 - Flexible 5-pipeline architecture
 - Four concurrent outputs
 - New 4:2:0 format (NV12) for interoperability with video system
 - Programmable color space conversion
 - Programmable scaling
 - HW overlaying
 - Alpha blending
 - Memory to memory capability
 - Maximum display resolution up to 1920x1200 per interface: simultaneous use of multiple displays will reduce maximum resolution, subject to DDR bandwidth and graphics layers.

GStreamer Plugin for DSS

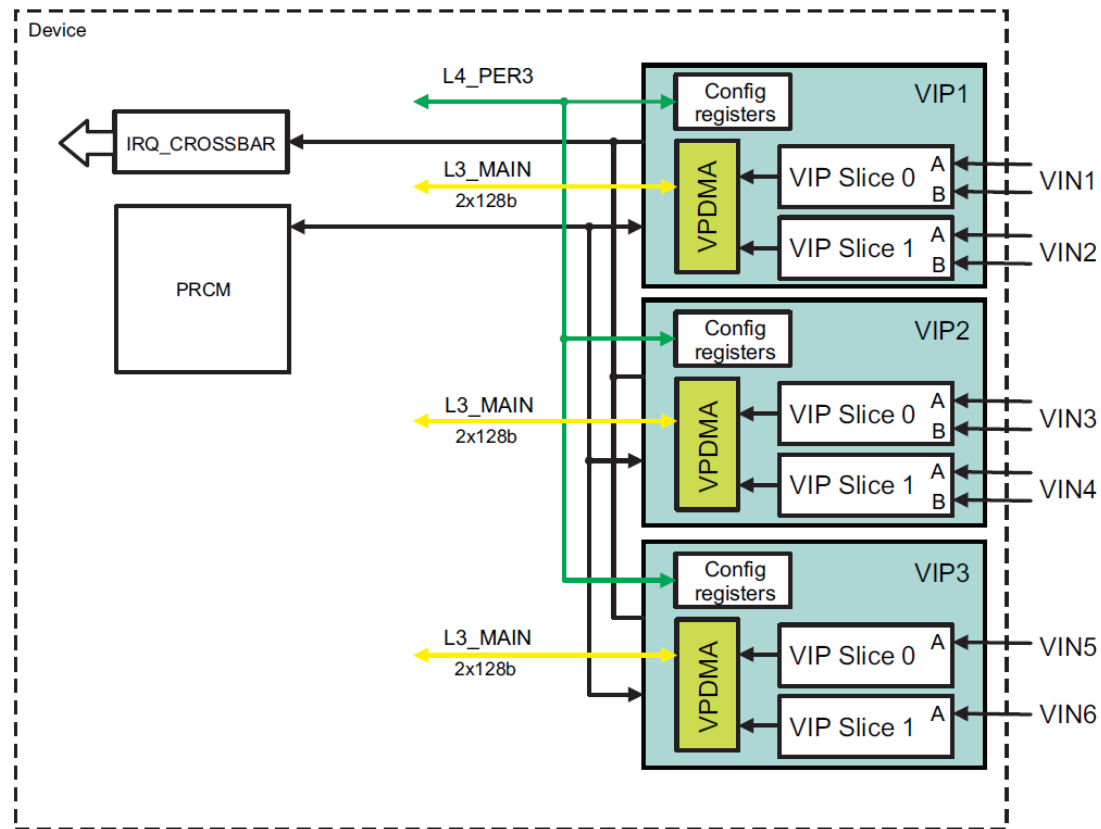
gst-inspect-1.0 kmssink



Video Input Port (VIP)

AM57x Multimedia and Graphics Functions

Video Input Port (VIP)



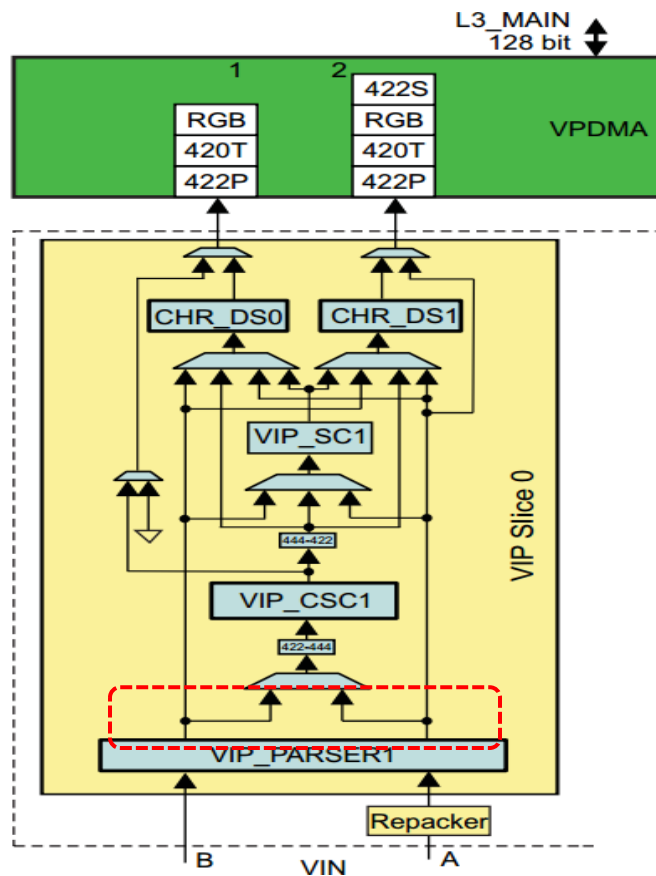
Video Input Capture Ports (VIP):

Each VIP supports 2-input independent stream parser slices:

- VIP1 and VIP2 slice can handle two streams:
 - Port-A: 8/16/24-bit options
 - Port-B: 8-bit only
- VIP3 slice can handle one stream:
 - Port-A: 8/16-bit options
- Supports both embedded-sync and discrete-sync input stream
- Ancillary data capture/storage (blanking data)
- On-the-fly scaling/format conversions
- Color space conversion

NOTE: AM571x does not have VIP2 and VIP3

VIP (Stream Processing Slice)



Each VIP slice features the following

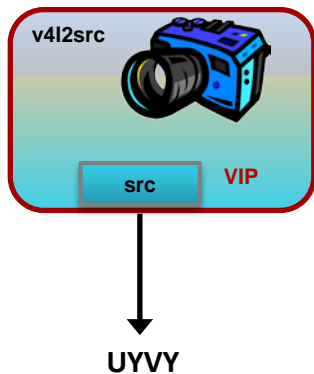
- Vid_Parser (input stream parser)
 - Input data repacker on PORT_A
 - Each parser can handle two streams
 - Port-A: 8/16/24-bit configuration
 - Port-B: 8-bit configuration
 - Supports both embedded sync and discrete sync:
 - Embedded sync stream can be single or (2x or 4x pixel or line) multiplexed stream (BT656, BT1120)
 - Discrete sync modes support various sync combinations: VS+HS, VS+ACTVID+FD, VB+ACTVID+FID
 - Input size limited by pixel clock rate only
 - Ancillary data capture (blanking data)
- Programmable color space conversion: (RGB <->YUV)
- Scaler (same as the scaler in VPE) used as downscaler only in VIP
- Dual-chroma down samplers (422 → 420)
- VDPMA supports both raster and tiled outputs

VIP Software Support

- VIP Slice:
 - Slice0: **supported**
 - Slice1: **supported**
 - PortA of either Slice: **supported**
 - PortB: **will be supported in linux kernel version 4.1**
- VIP Parser:
 - Repacker: **supported** but not enabled given input are 8 bits there is no point at the moment.
 - Embedded Sync (BT.656 8/16/24 bits & BT.1120 16/24 bits): **supported**
 - Discrete Sync 8/16/24 bits: **supported**
 - Stream multiplexing in Embedded Sync mode: **supported**
 - Interlaced (top/bottom field): **supported**
 - Cropping: **not supported**
- VIP Color Space Converter: **not supported**
- VIP Scaler: **not supported**
- VIP VPDMA: **supported**
- VIP Chroma Downsampling
 - The only exception is if the sensor supports YUYV, then NV12 is also supported

GStreamer Plugin to Interact with VIP

gst-inspect-1.0 v4l2src



Graphics Acceleration

AM57x Multimedia and Graphics Functions

Graphics Acceleration

- Dual (AM572x) / Single (AM571x) Imagination SGX544 3D graphics engine:
 - Up to 532 MHz
 - API support for OpenGL® ES1.1 & 2.0
 - Tile-based architecture reduces access to external memory
 - Universal Scalable Shader Engine (USSE™):
 - Multi-threaded engine incorporating vertex and pixel shader functionality
 - Automatic load balancing of vertex and pixel processing tasks
 - Present and Texture Load Accelerator (PTLA):
 - Enables move, rotate, twiddle, and scale of texture surfaces
 - Supports RGB, ARGB, YUV4:2:2, and YUV4:2:0 surface formats
 - Supports bilinear upscale
 - Supports source color key
- Vivante Corporation GC320 2D graphics accelerator:
 - API support for OpenWF™, DirectFB, and GDI/DirectDraw™
 - Also supports BitBlt, StretchBlt, blending, and transparency

Software Architecture

AM57x Sitara™ Processors Multimedia and Graphics

Multimedia Software Stack Overview

MPU Subsystem
Cortex-A15

Linux User Space Application

Wayland

Gstreamer

GST-Ducati Plugin

libdrm

libdce

OMAP DRM

OMAP DSS

Linux Operating System Kernel

Legend

TI Software

TI&Community
Software

Community
Software

User Software

DRM: Digital Rendering Manager
DSS: Display Subsystem
DCE: Distributed Codec Engine
IVA: Image and Video Accelerator

IPU Subsystem
Cortex-M4

DCE Server

Codec Engine

RPMSG

RPMSG

Framework
Components

IPC

SYS/BIOS RTOS

IVA

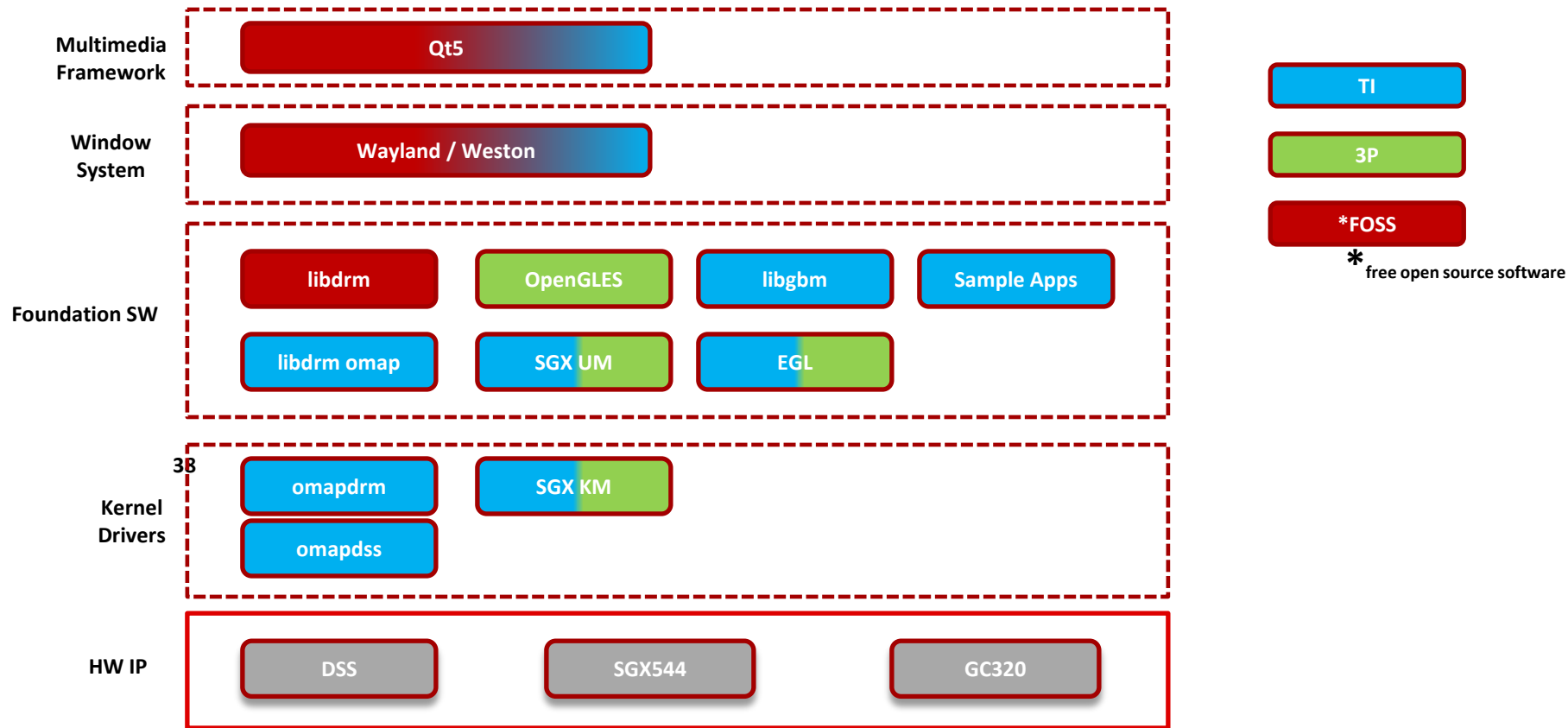
IVAHD Codecs

- Supported
 - GStreamer firmware only
- Not supported
 - Opening up of Cortex-M4 firmware
 - Customizations to video codec on IVA-HD (codec in binary format only)



TEXAS INSTRUMENTS

Graphics Software Stack Overview



For More Information

- [Processors Multimedia Training Wiki](#)
- [Graphics Display Getting Started Guide](#)
- [Processor SDK Release Notes](#)
- GStreamer <http://gstreamer.freedesktop.org>
- DRM over FBDev: http://e2e.ti.com/support/omap/int_omap/f/883/t/370105
- Wayland over X11: http://e2e.ti.com/support/omap/int_omap/f/883/t/371173
- For questions about this training, refer to the E2E Community Forum: <https://e2e.ti.com/support>