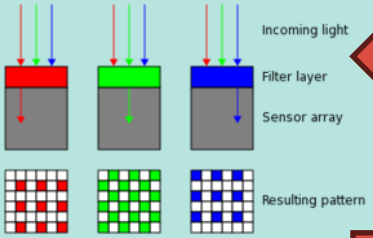
THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Composite Video Device Abstraction for Libcamera

Kamal Vedantham, Senior SDE, Amazon Lab126
Karthik Poduval, Principal SDE, Amazon Lab126

Complex ISP Pipeline



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I2C

CSI2

I2C Controller

CSI2/D-PHY Controller

Black Level Correction

Defective Pixel Correction

DMA

Statistics

Demosiac

Color Correction

DMA

Scaling/Color Space Correction

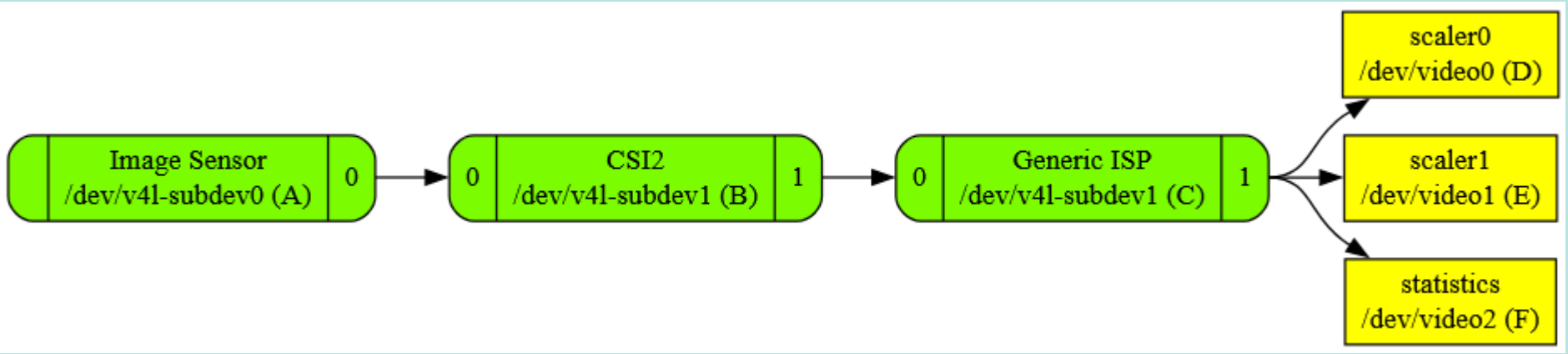
DMA

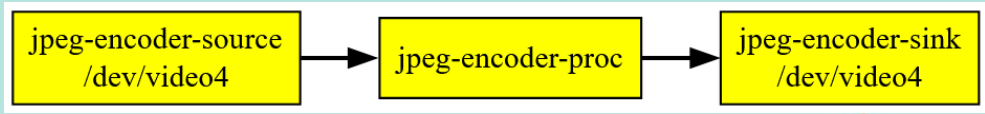
Dewarp

DMA

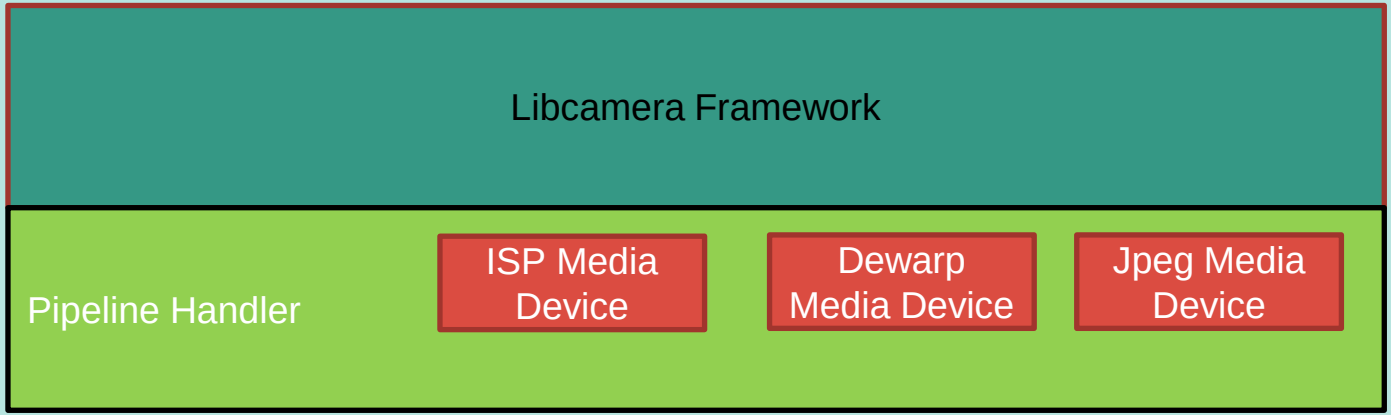
Jpeg Encoder

Complex ISP Pipeline (Media Graph View)





Libcamera


Libcamera Framework
Pipeline Handler
ISP Media Device
Dewarp Media Device
Jpeg Media Device

Libcamera Application View

- Visible as a 2 Stream Camera
- Each Stream is RGB888 (native from ISP)
- Each Stream can optionally be dewarped and also send for JPEG encoding
- Pipeline Handler needs to decide post processing or not based on
  - Stream Format JPEG needs JPEG encoder
  - The Dewarping of streams is a static policy ex: enforced on certain resolutions

Pipeline Handler Implementation Choices

- Simple Method
  - Match for all 3 media devices i.e. isp, dewarp, jpeg-encoder
  - Decide to pass frame to dewarp (based on static policy)
  - Decide to pass frame to JPEG Encoder if JPEG format is chosen
- With Composite Video Device Abstraction
  - Pipeline handler see's 2 CompositeVideoDevices that encapsulate
    - All capabilities of Video Device
    - All capabilities of post processors
    - Handle the complications like
      - Intermediate Buffer Allocations
      - Setting/Getting formats
      - Setting/Getting controls
      - Orchestrating callbacks

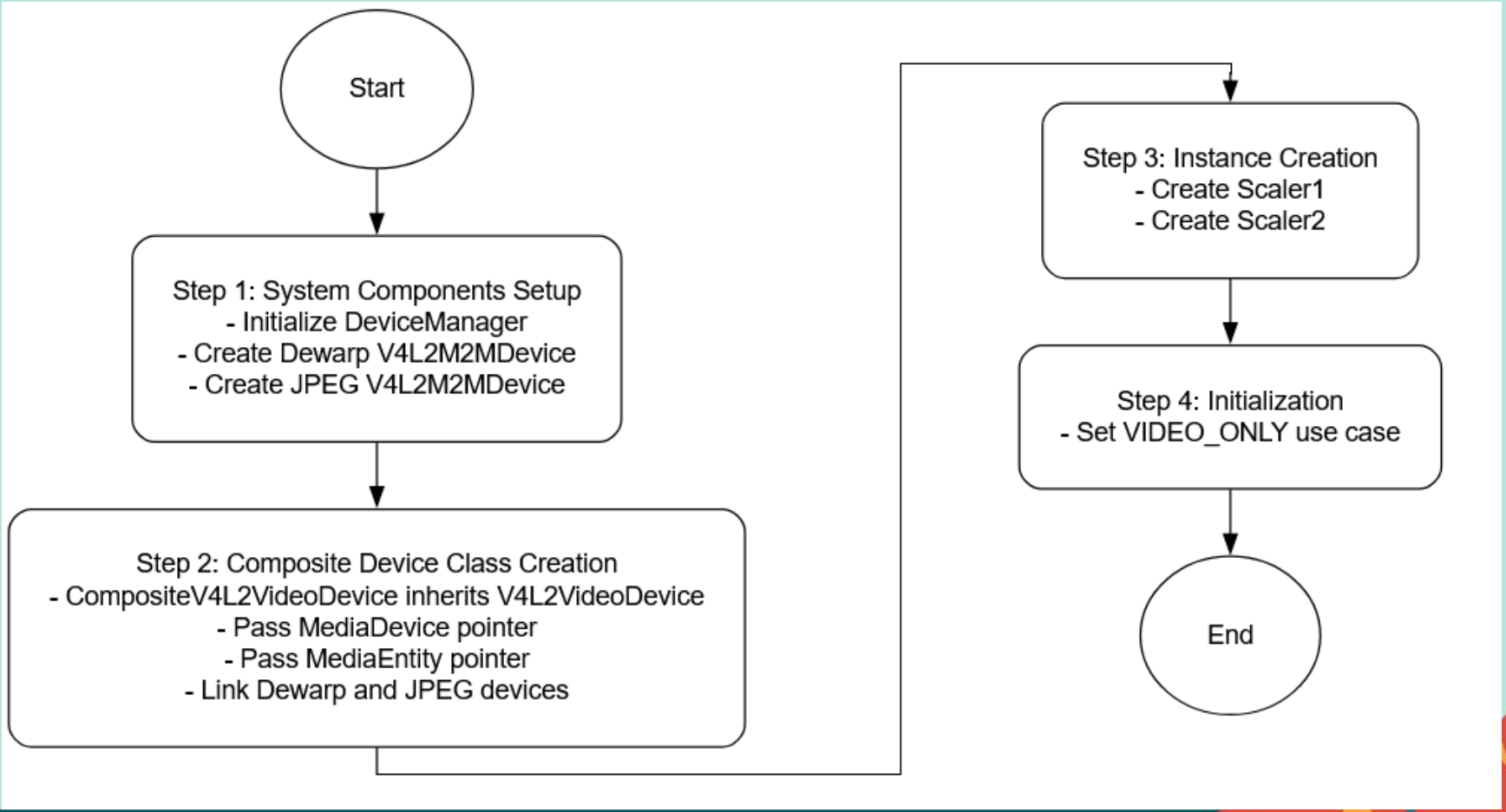
Composite Video Device Abstraction

- Instead of manually controlling the callbacks between video device and post processors, build a composite device abstraction
- The combination of V4L2VideoDevice and V4L2M2M based post processors is abstracted as a single class called CompositeV4L2VideoDevice
- C++ class inheritance technique used to provide this abstraction
- The convenience class makes pipeline handler code simplified

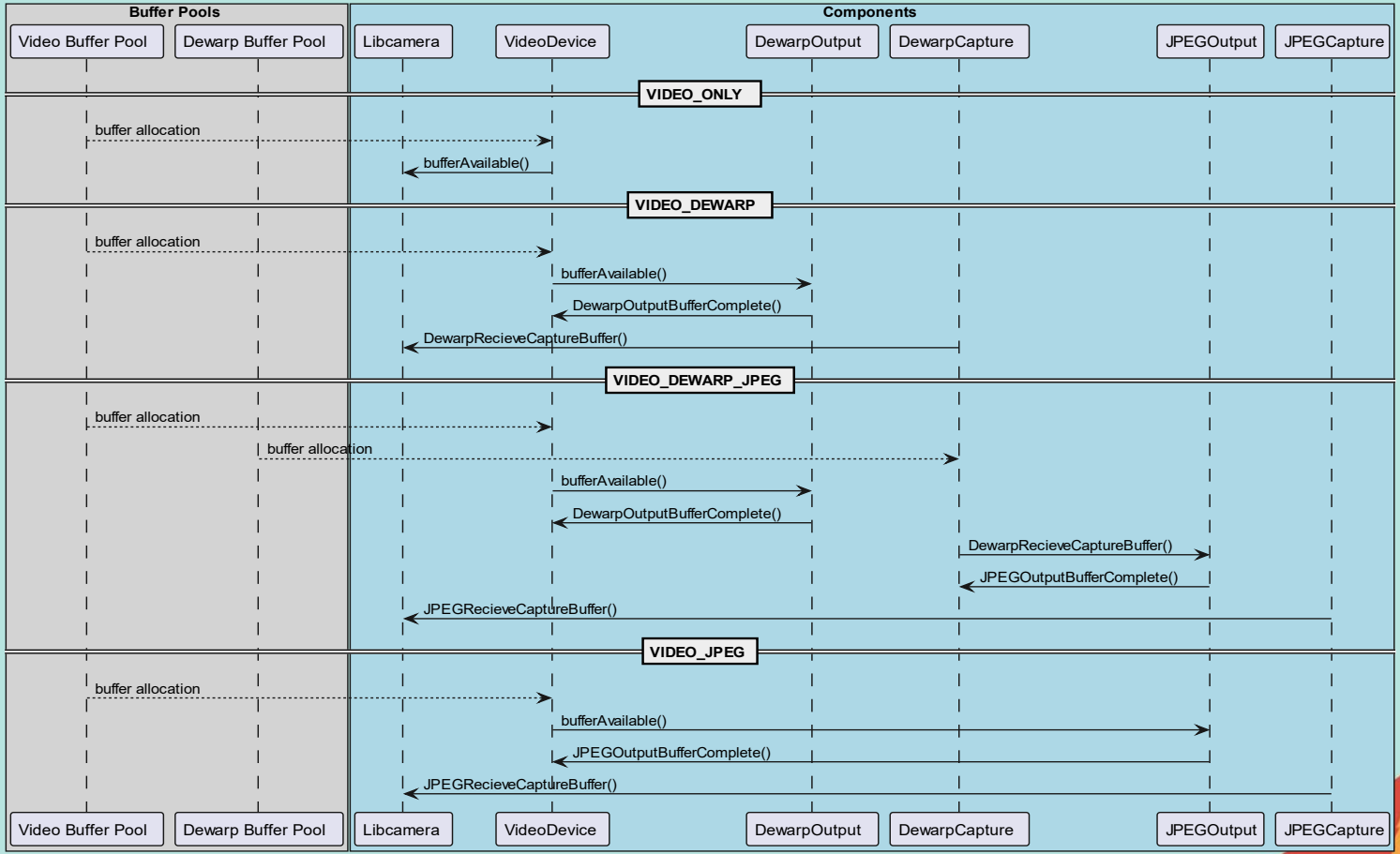
CompositeV4L2VideoDevice

CompositeV4L2VideoDevice

- All methods from V4l2VideoDevice supported
- All actions taken based on the CompositeDeviceUseCase class variable
- UseCase gets set based on
  - Static Policy (Dewarp or not)
  - SetFormat (if JPEG then JPEG based use case selected)
- Video Device in the end of a pipeline is imports buffers
- Intermediate Buffers between video device and multiple post processors managed by the class


Start
Step 1: System Components Setup
- Initialize DeviceManager
- Create Dewarp V4L2M2MDevice
- Create JPEG V4L2M2MDevice
Step 2: Composite Device Class Creation
- CompositeV4L2VideoDevice inherits V4L2VideoDevice
- Pass MediaDevice pointer
- Pass MediaEntity pointer
- Link Dewarp and JPEG devices
Step 3: Instance Creation
- Create Scaler1
- Create Scaler2
Step 4: Initialization
- Set VIDEO_ONLY use case
End

Function	VIDEO_ONLY	VIDEO_DEWARP	VIDEO_DEWARP_JPEG	VIDEO_JPEG
StreamOn	base stream on	• base stream on • Dewarp Output Stream on • Dewarp Capture Stream on	• base stream on • Dewarp Output Stream on • Dewarp Capture Stream on • JPEG Output Stream on • JPEG Capture Stream on	• base stream on • JPEG Output Stream on • JPEG Capture Stream on
StreamOff	base stream off	• base stream off • Dewarp Output Stream off • Dewarp Capture Stream off	• base stream off • Dewarp Output Stream off • Dewarp Capture Stream off • JPEG Output Stream off • JPEG Capture Stream off	• base stream off • JPEG Output Stream off • JPEG Capture Stream off


Buffer Pools
Components
Video Buffer Pool
Dewarp Buffer Pool
Libcamera
VideoDevice
DewarpOutput
DewarpCapture
JPEGOutput
JPEGCapture
VIDEO_ONLY
buffer allocation
bufferAvailable()
VIDEO_DEWARP
buffer allocation
bufferAvailable()
DewarpOutputBufferComplete()
DewarpRecieveCaptureBuffer()
VIDEO_DEWARP_JPEG
buffer allocation
buffer allocation
bufferAvailable()
DewarpOutputBufferComplete()
DewarpRecieveCaptureBuffer()
JPEGOutputBufferComplete()
JPEGRecieveCaptureBuffer()
VIDEO_JPEG
buffer allocation
bufferAvailable()
JPEGOutputBufferComplete()
JPEGRecieveCaptureBuffer()
Video Buffer Pool
Dewarp Buffer Pool
Libcamera
VideoDevice
DewarpOutput
DewarpCapture
JPEGOutput
JPEGCapture

Questions ?

References

- https://libcamera.org/
- https://docs.kernel.org/driver-api/media/v4l2-mc.html