Leveraging OpenCL to create differentiation

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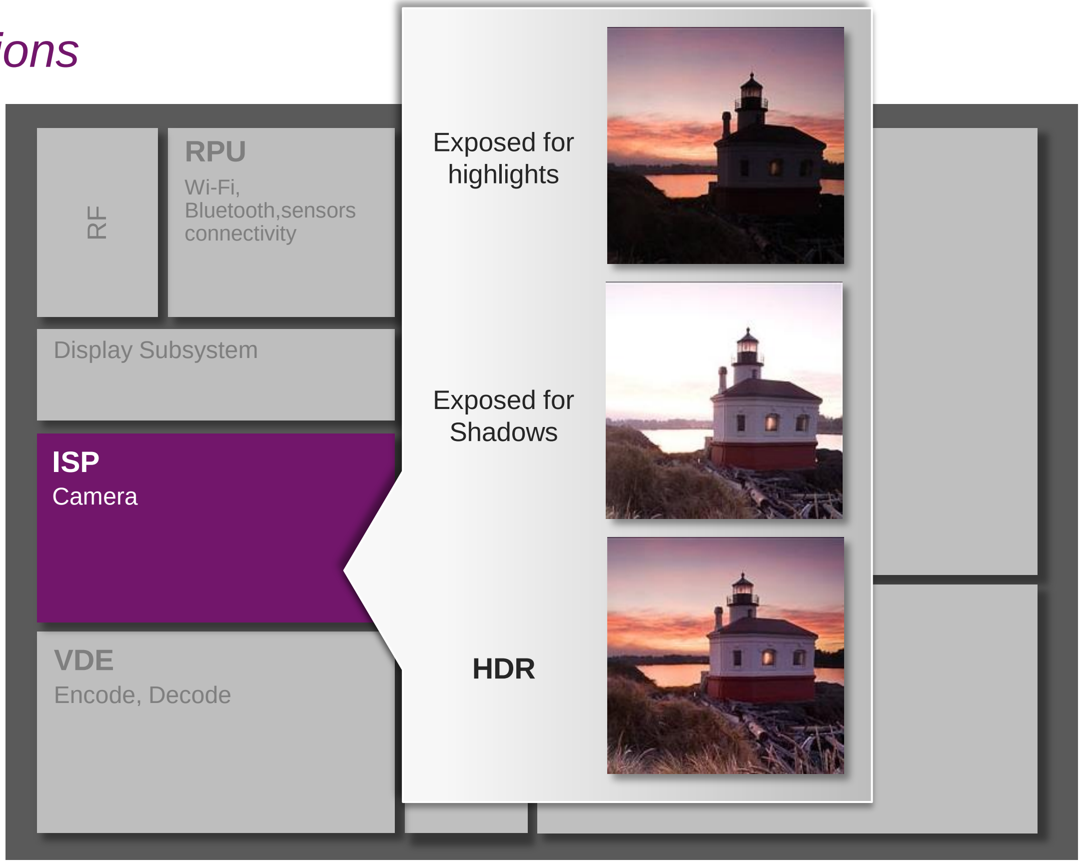
Today's opportunity

Differentiated multimedia applications

- Android's expanded camera subsystem now modelled after professional camera
- In an attempt to maintain a consistent platform running on multiple SoCs, Google limits rate of adoption of new features

Android version	Camera HAL	Addition to android.camera.hal
Lollipop		Noise reduction
KitKat	3.1	*None*
JB MR2	3.0	*None*
JB MR1	2.0	HDR
JB		Auto focus
ICS		Video stabilization
ICS	1.0	Face detection

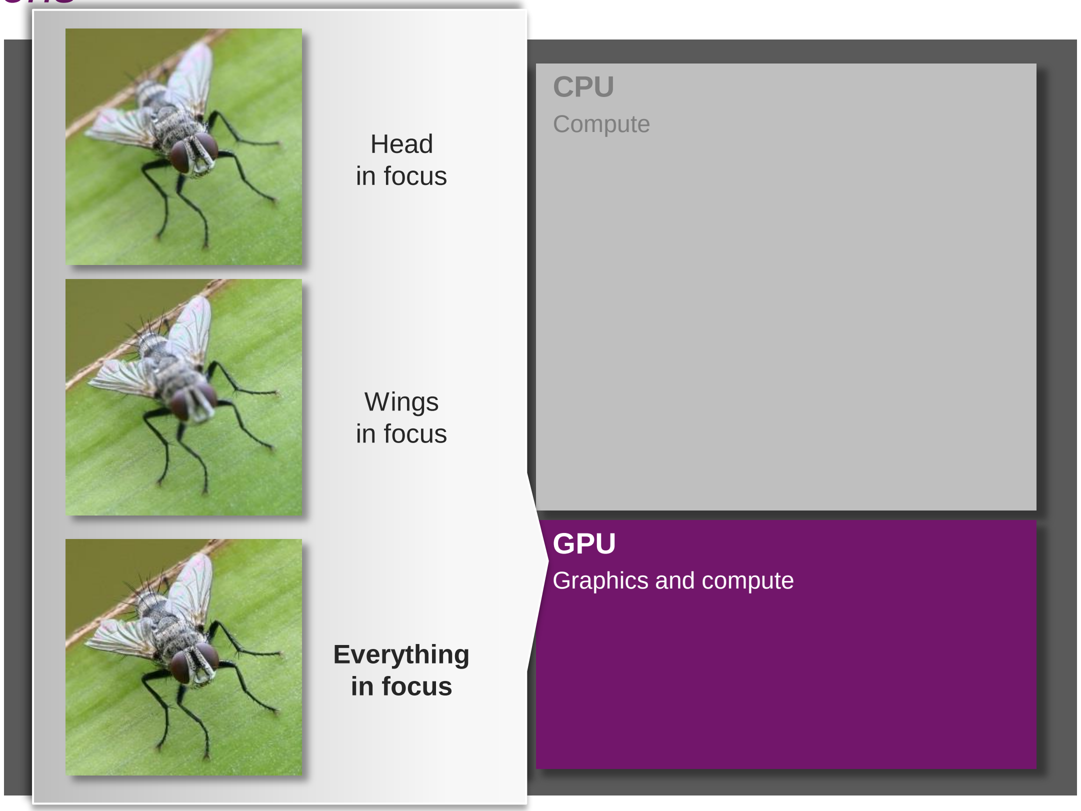


Today's opportunity

Differentiated multimedia applications

- OEMs will choose SoCs that allow them to differentiate their Android products
- Features most requested are computational photography and computer vision:
  - Sensor processing – stereo, array and ToF
  - Panoramas – real-time and high-res
  - Depth of field (focus stacking)
  - Gesture recognition
  - Augmented reality – real lighting
- Bringing new features to market fast requires:
  - large amounts of processing power
  - programmability

GPU compute delivers high performance for many image processing algorithms

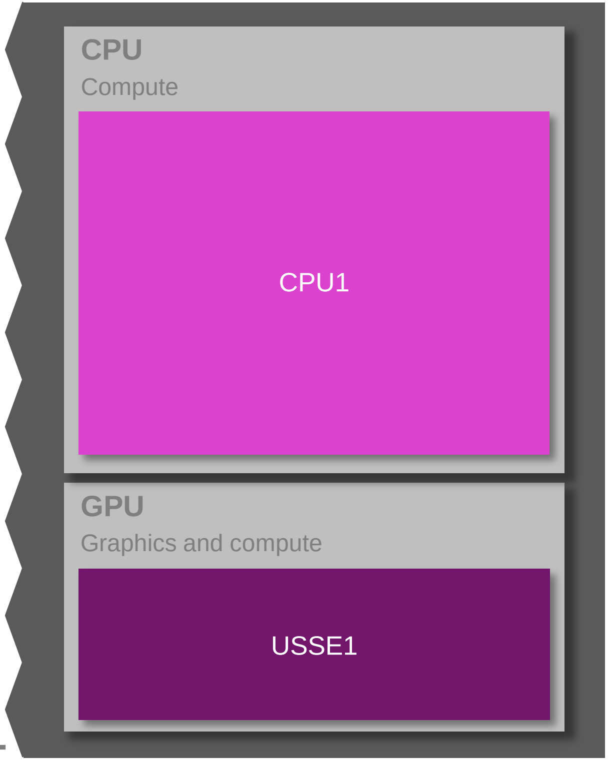


GPU increasingly dominates SoC area

Particularly in premium SoCs

- SMP configurations unlikely to scale efficiently beyond four CPUs
- GPU multi-processor and multi-pipe configurability enables far more extensive processor scaling
- *OpenCL unlocks the full potential of GPUs*

65nm SoC



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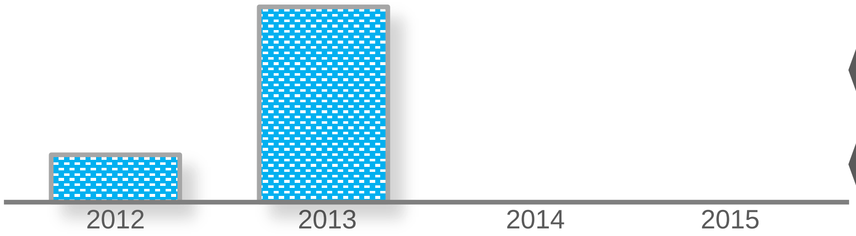
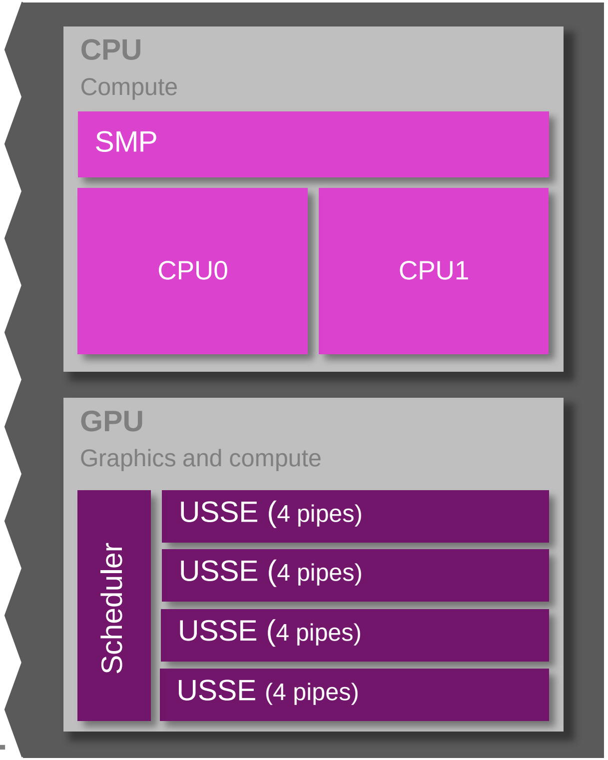


40nm SoC



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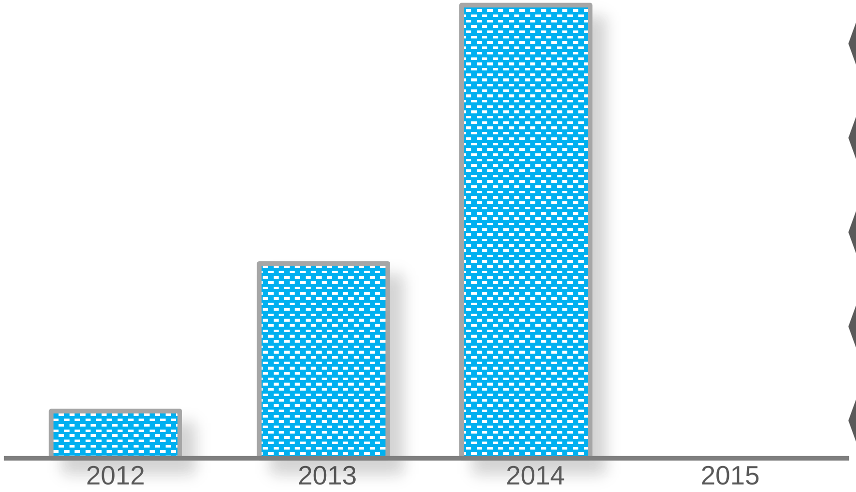
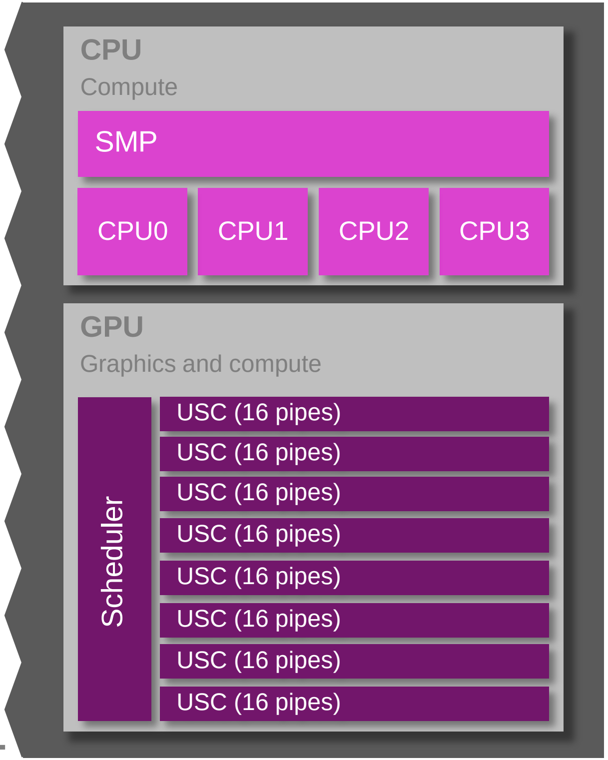


28nm SoC



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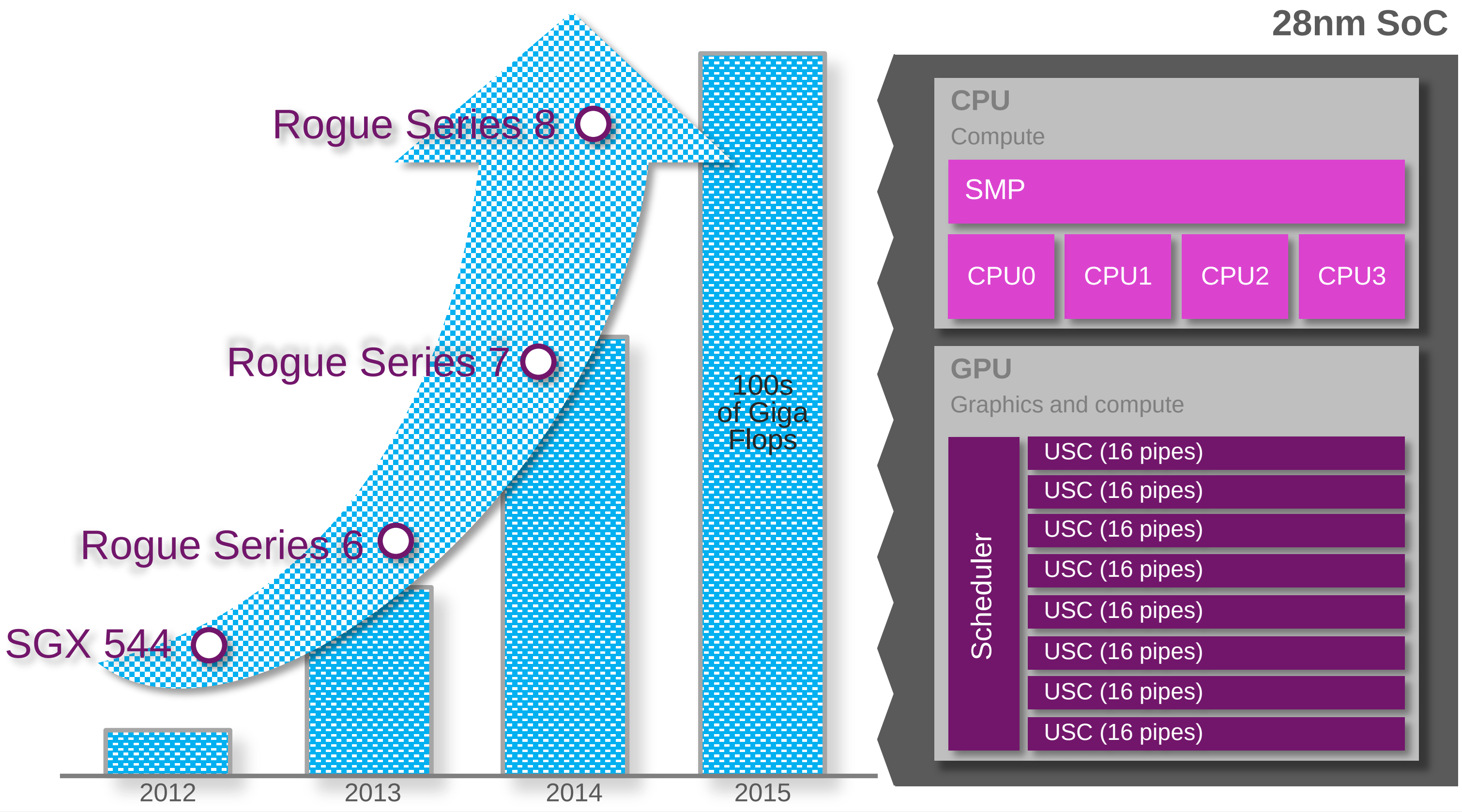
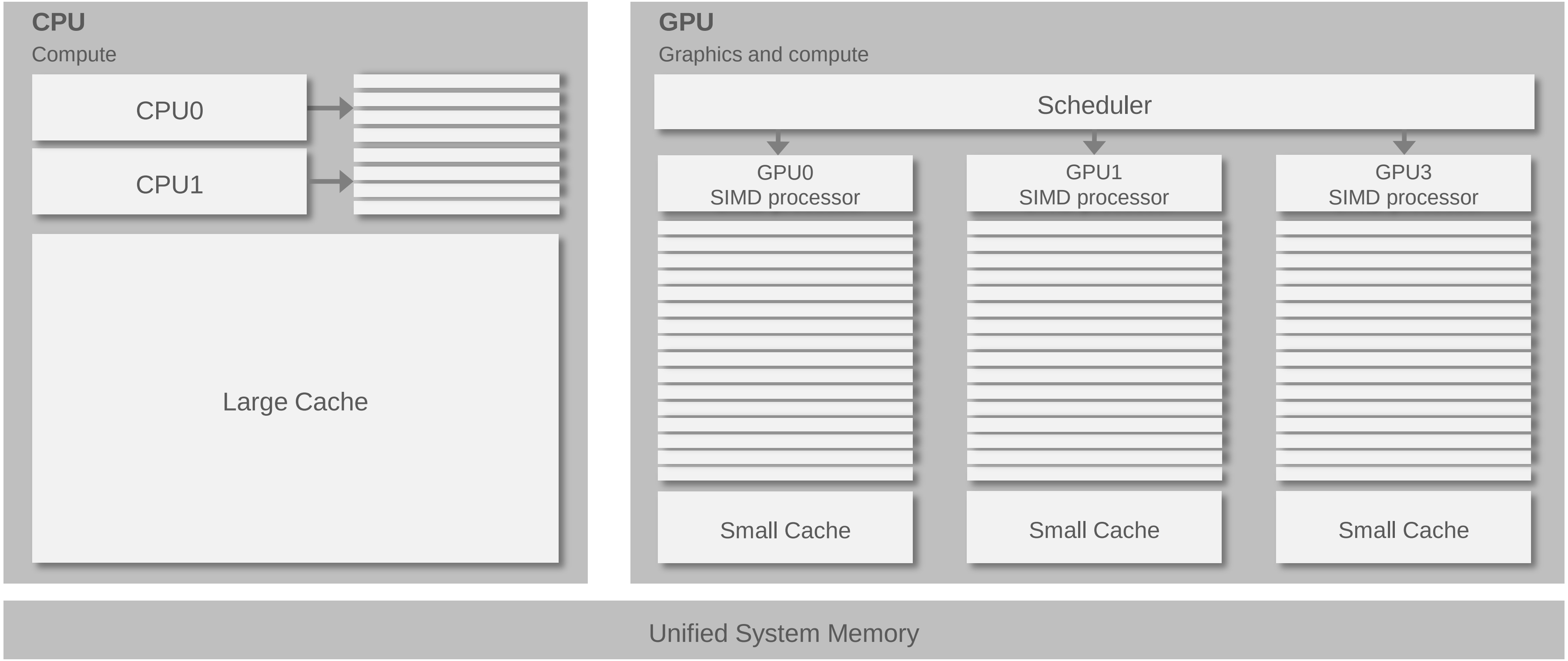


GPU compute – more performance, less power

The correct application partitioning is critical to success



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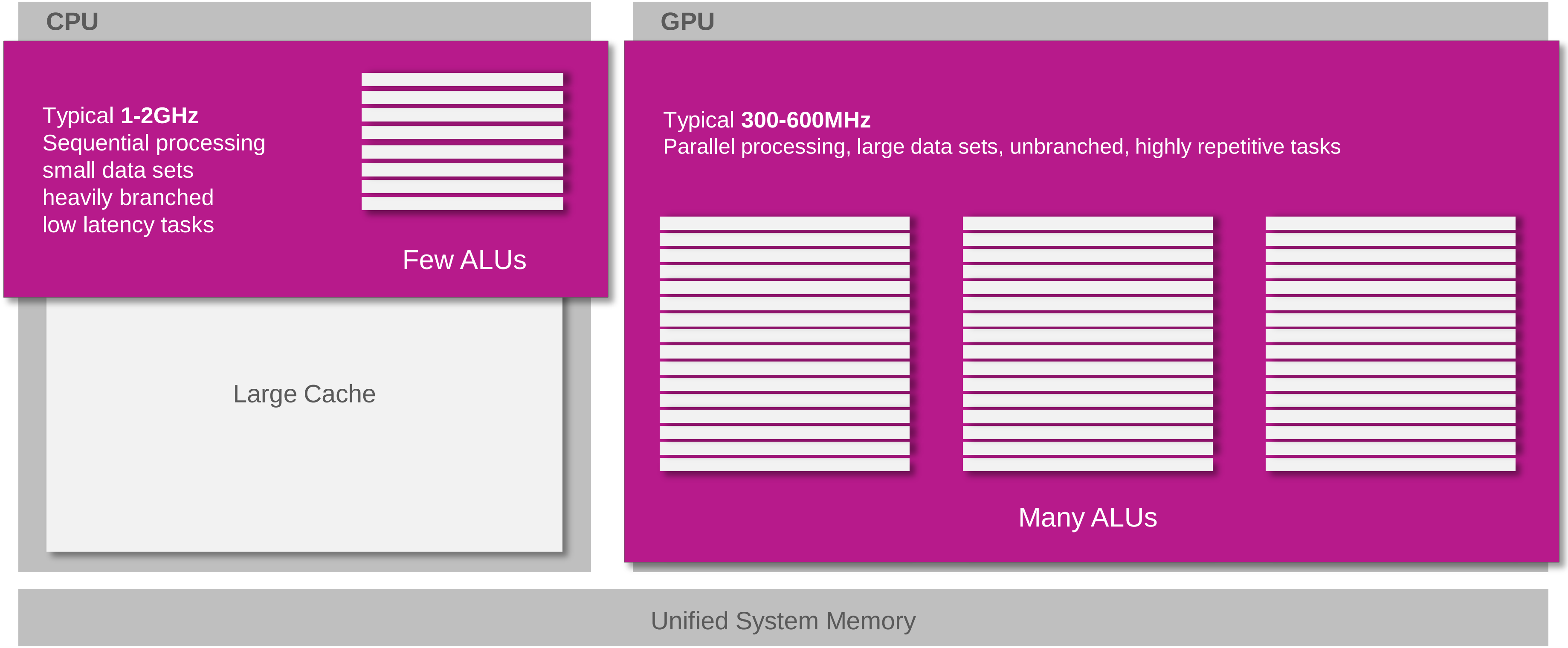
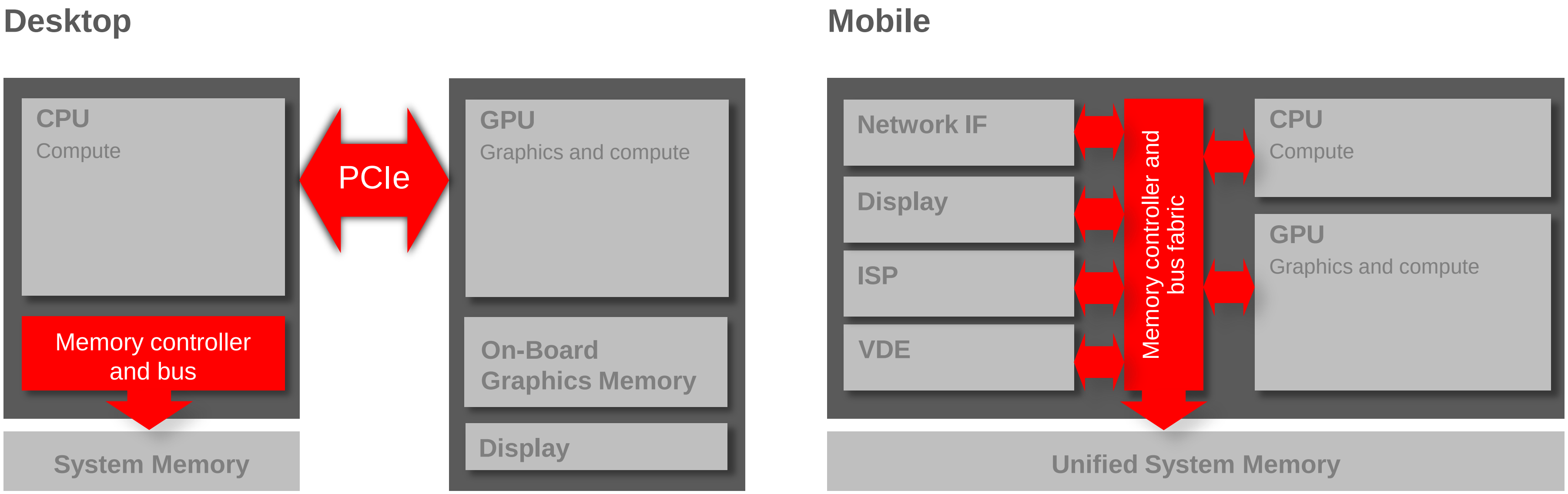


The problem with SoC bandwidth

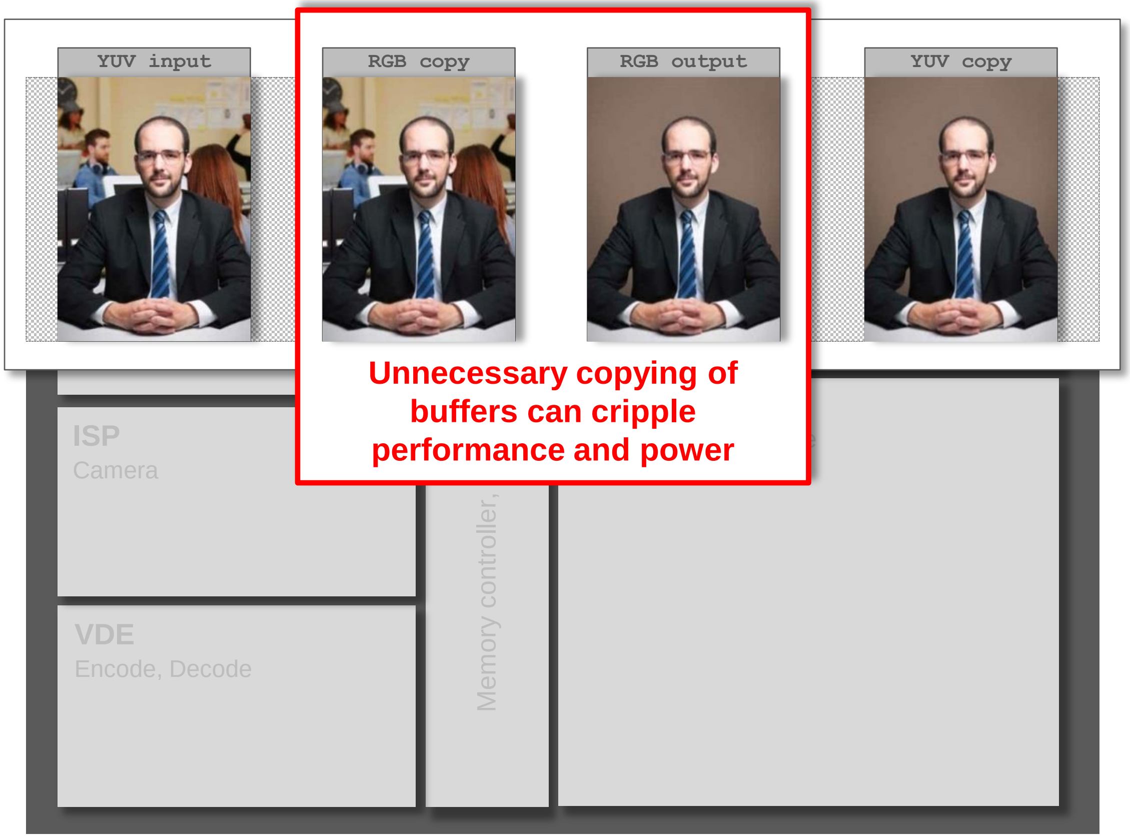
SoC bandwidth is usually much more constrained than on desktop machines



- In mobile SoCs the Unified system memory is shared between all the I.P. blocks

Android's problem with buffer copies

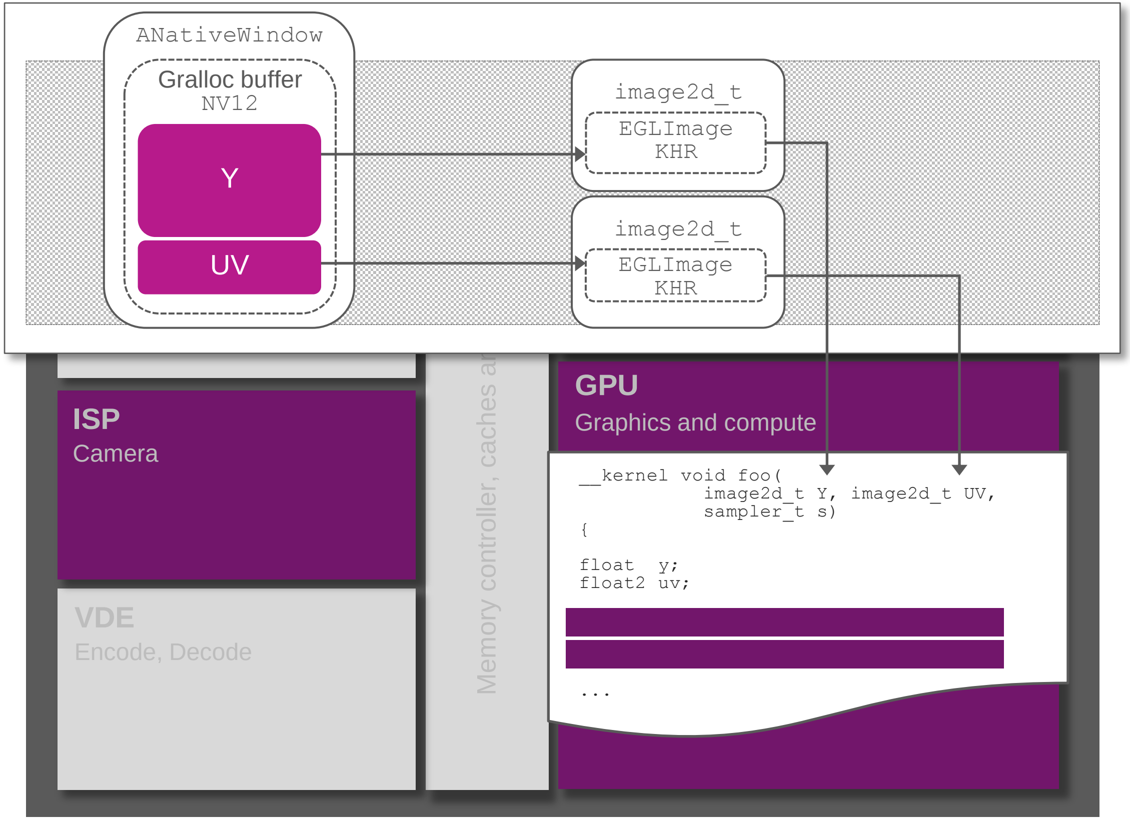
- Android dictates the formats of camera and video data presented to apps developers
- The OS APIs may copy frames from one format to another
  - **Unnecessarily increases bandwidth**
  - **Unnecessarily reduces achievable GPU compute performance**
- Performance losses can be quickly compounded, especially when processing HD video content



Zero-copy software: no redundant buffer copies

Direct processing of YUV semi-planar images

- Create an Android gralloc buffer, and create a native window from this buffer
- Use Imagination's PowerVR Imaging Framework for Android to bind the gralloc buffer to the camera HAL
- Call `eglCreateImageKHR` with a special flag to create two or three `EGLImageKHR` images that point to the YUV planes
- Call `clCreateFromEGLImageKHR` to create OpenCL Image objects
- In the kernel, call `read_imagef` to sample Y, U and V values



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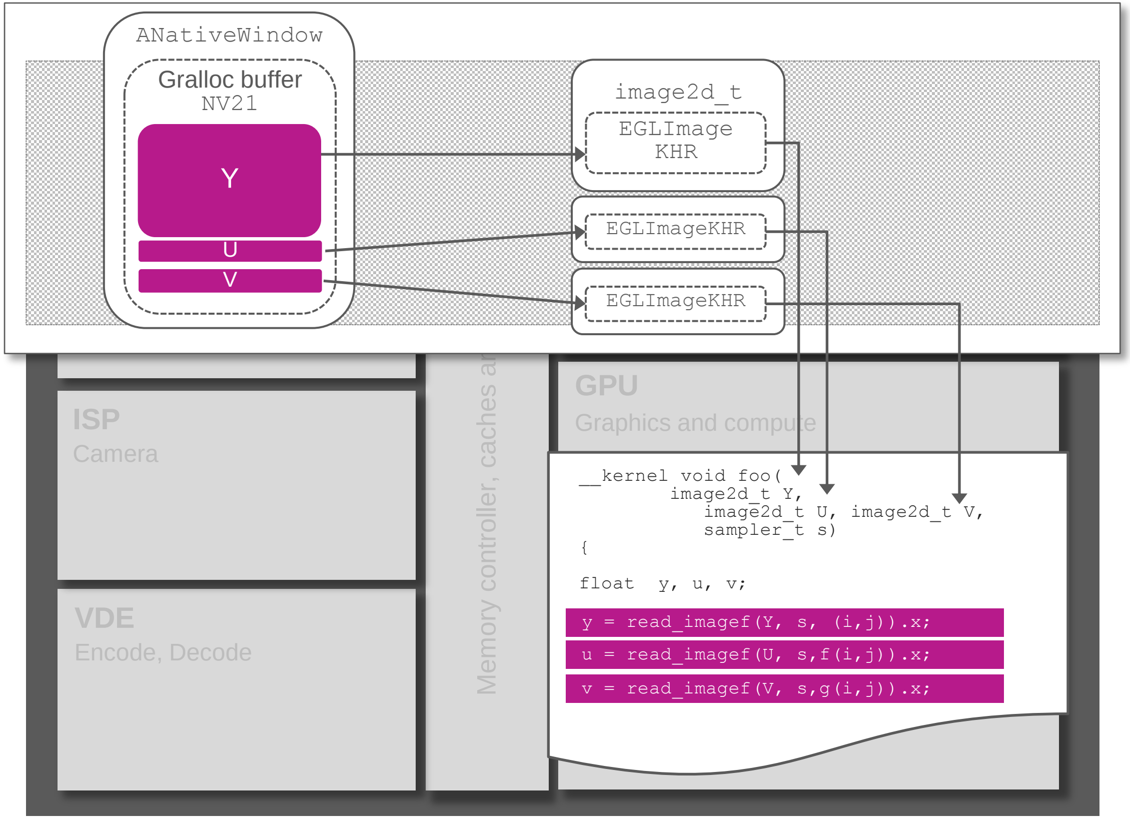
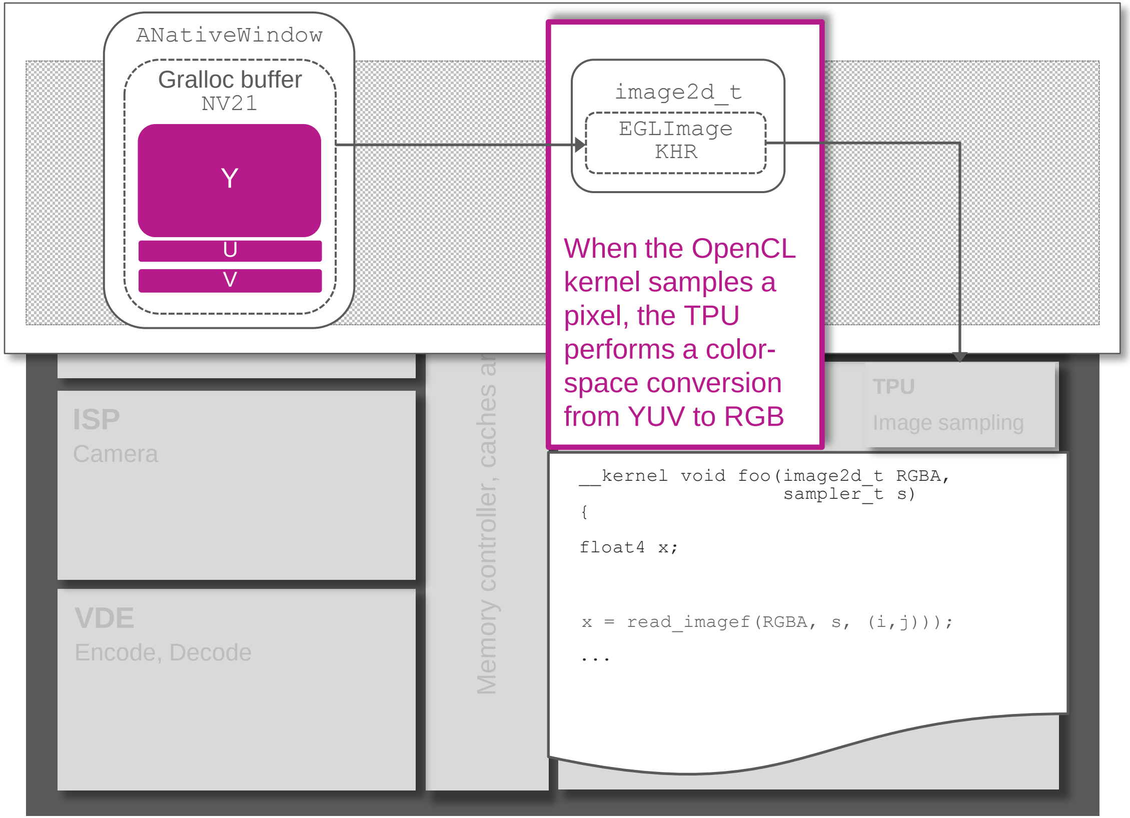


Zero-copy software: no redundant buffer copies

Dynamically converting pixels from YUV to RGB color space

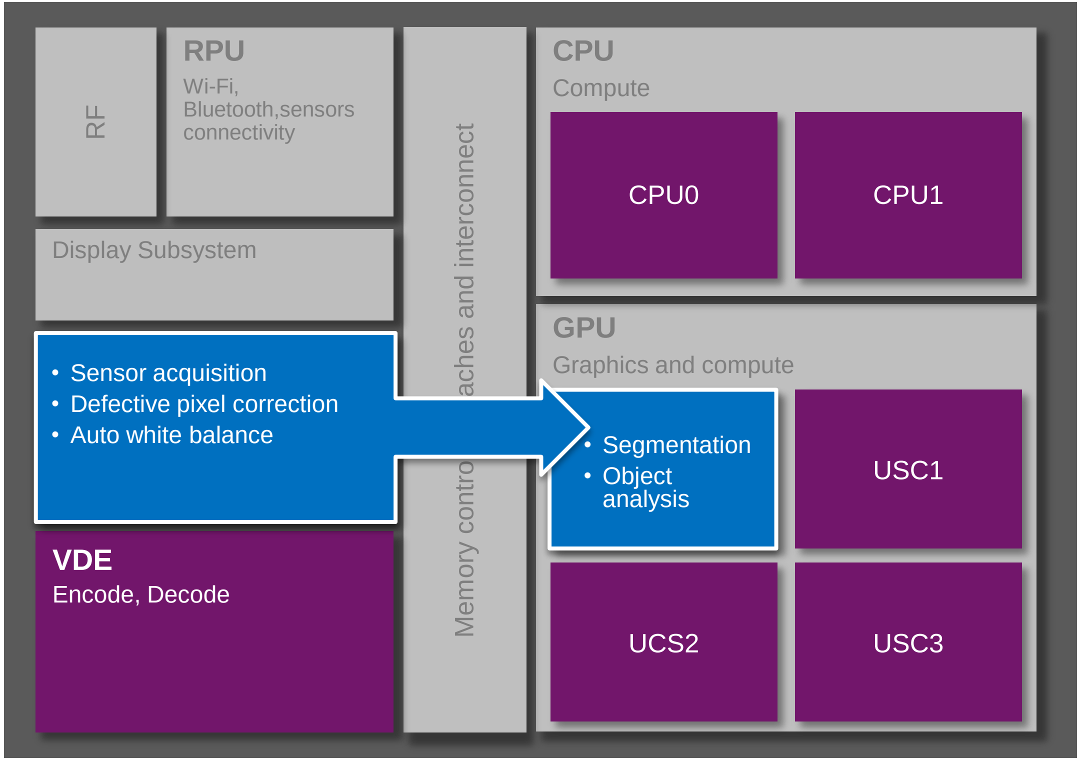
- Create an Android gralloc buffer, and create a native window from this buffer
- Use Imagination's PowerVR Imaging Framework for Android to bind the gralloc buffer to the camera HAL
- Enable the extension CL_IMG_YUV_image and call `eglCreateImageKHR` to create one `EGLImageKHR` image that points to the YUV image
- Call `clCreateFromEGLImageKHR` to create an OpenCL Image object
- In the kernel, call `read_imagef` to sample RGB values



PowerVR Imaging Framework for Android

Zero-copy extensions that OEMs need to enable differentiation

- A suite of *software extensions* that enables efficient interoperability of software running on PowerVR GPUs with many other SoC hardware blocks
- Interoperable with
  - CPU
  - ISP
  - VDE
- Images produced by the ISP can be directly consumed by the GPU



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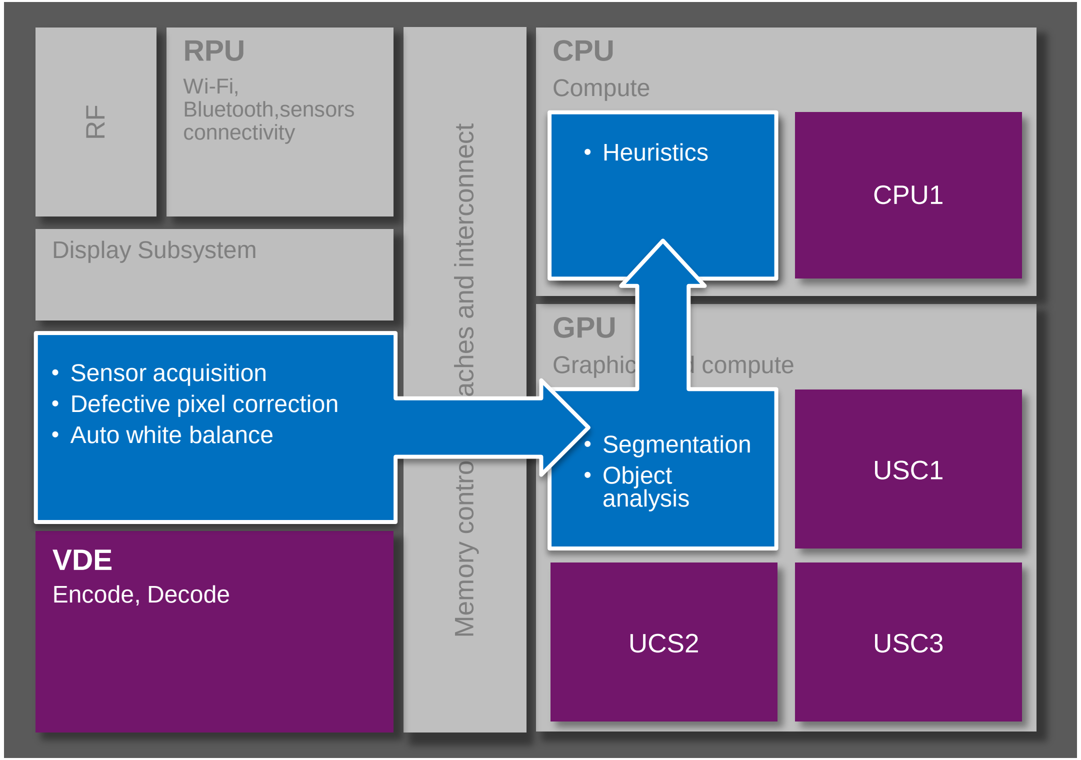
- Images produced by the ISP can be directly consumed by the GPU
- Images produced by the GPU can be directly consumed by the CPU
- Many complex vision and computational software pipelines can be created, incorporating the VDE and other compatible hardware on the SoC

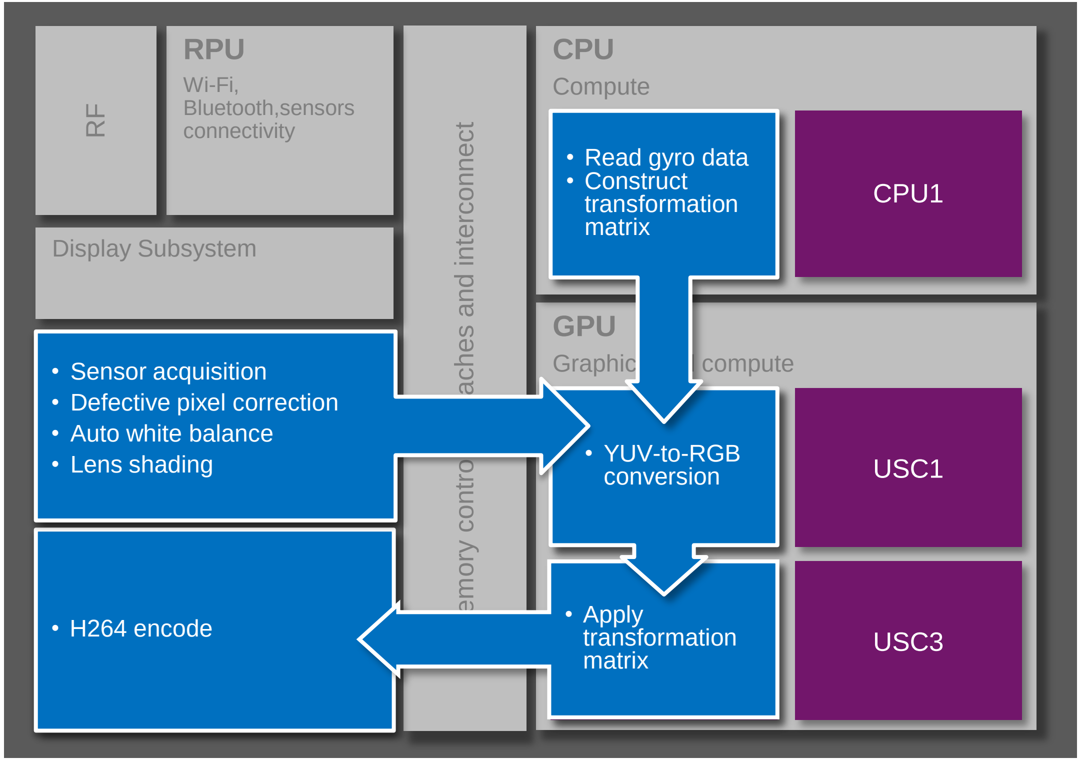


PowerVR imaging framework examples

Image Stabilization

Without GPU compute **With GPU compute**

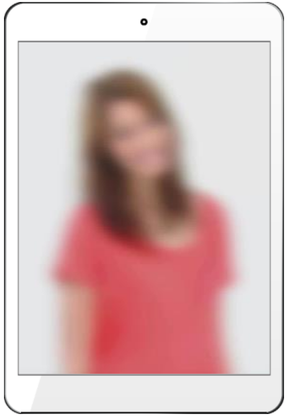
- Reduces frame-to-frame jitter when user is walking/in motion
- Provides smooth recording and playback of user-generated content
- Improves low-light performance



PowerVR imaging framework examples

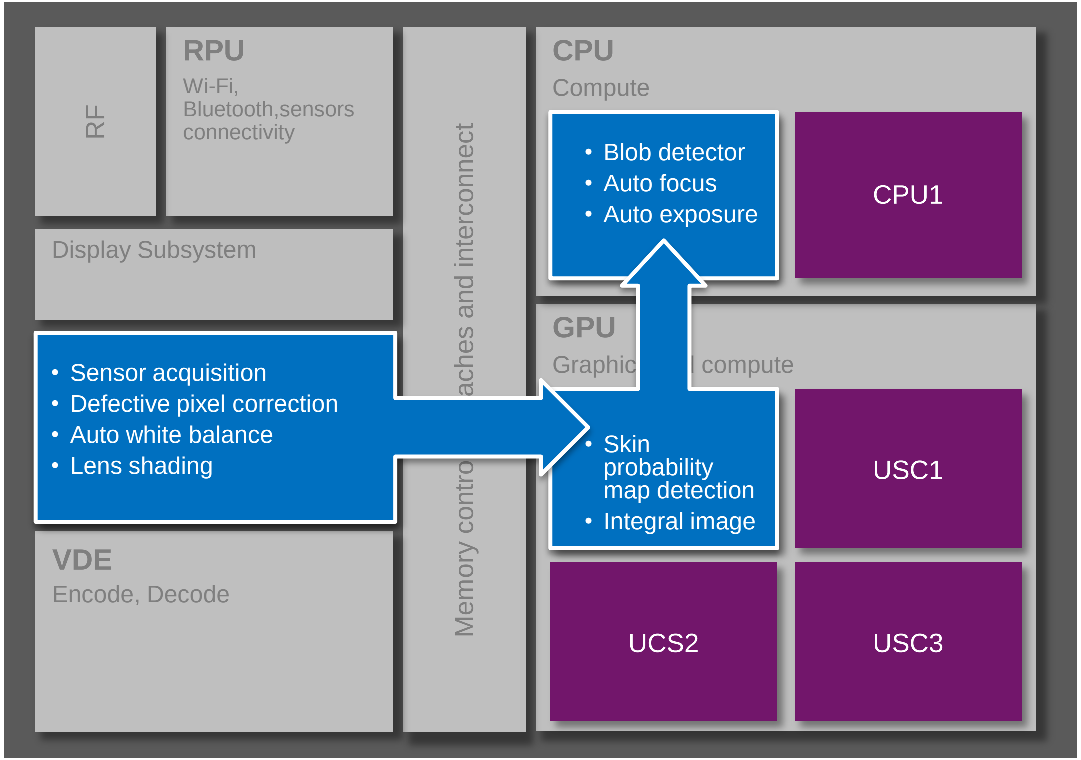
Face Detection

Without GPU compute



With GPU compute

- Accurate face detection enables camera auto-focus and auto-exposure
- Enables selective high-fidelity encoding of key regions of interest (and bit-rate savings on background)



Case study: Image processing on MT8135

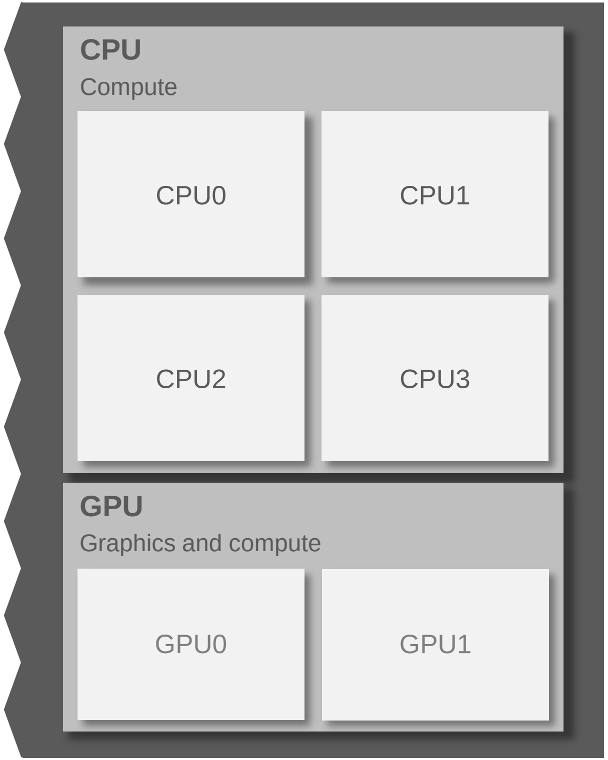
Simple 3x3 edge detection on Y component

```
__kernel __attribute__ ((reqd_work_group_size(32, 1, 1)))
void edgeDetect (__read_only image2d_t srcImageY, __write_only image2d_t
dstImageY)
{
  sampler_t sampler = CLK_NORMALIZED_COORDS_FALSE |
                      CLK_ADDRESS_CLAMP_TO_EDGE   |
                      CLK_FILTER_NEAREST;

  int2 coords = (int2)( get_global_id( 0 ), get_global_id( 1 ) );

  float luma;
  luma  = read_imagef( srcImageY, sampler, coords + (int2)(  1,  0 ) ).x;
  luma += read_imagef( srcImageY, sampler, coords + (int2)(  0,  1 ) ).x;
  luma += read_imagef( srcImageY, sampler, coords + (int2)(  1,  1 ) ).x;
  luma -= read_imagef( srcImageY, sampler, coords + (int2)( -1, -1 ) ).x;
  luma -= read_imagef( srcImageY, sampler, coords + (int2)(  0, -1 ) ).x;
  luma -= read_imagef( srcImageY, sampler, coords + (int2)( -1,  0 ) ).x;

  write_imagef( dstImageY, coords, luma );
}
```



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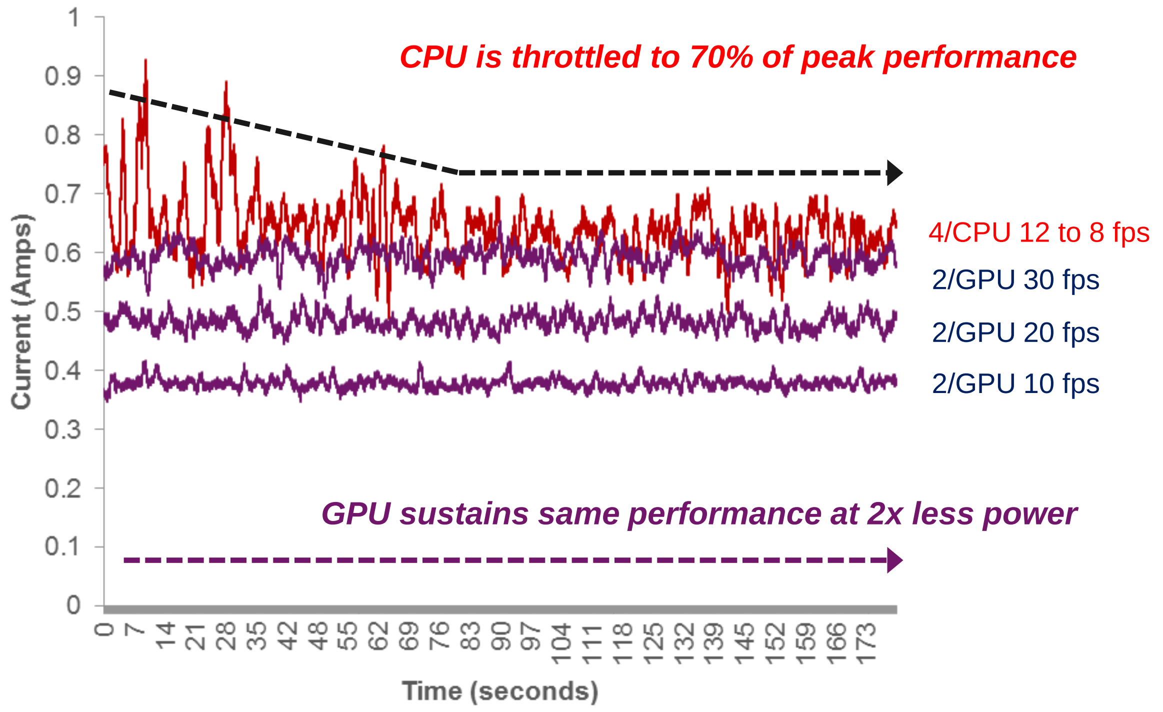
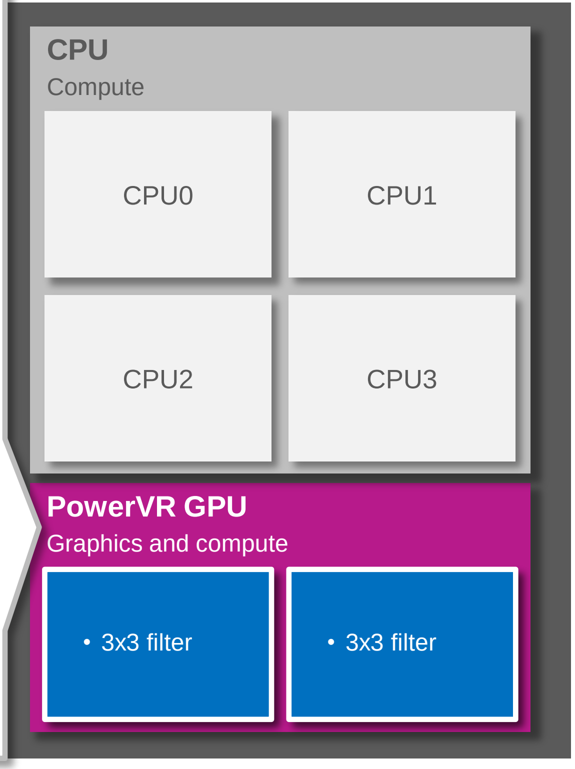
Free-running 1080p camera processing using CPU versus GPU



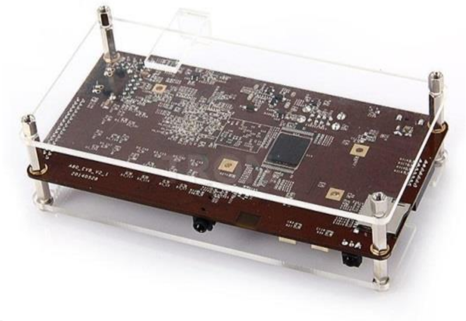
(Current measurement for board excluding backlight)



Developer boards

- Many developer boards and OEM products are now available in the market with a PowerVR Rogue GPU and OpenCL driver
- Most platforms now support PowerVR imaging framework extensions

Merrii OptimusBoard
AllWinner A80
Rogue **G6230**



Meizu MX4
MediaTek MT6595
Rogue **G6200**

ASUS ZenFone 2
Intel Atom Z3580
Rogue **G6430**

Dell Venue 7/8
Intel Atom Z3580
Rogue **G6430**

Conclusion

- OpenCL has been successfully deployed in 2015 mobile and tablet products to enable new camera and multimedia use cases
- Sensibly partitioning an application across all available components including an ISP, CPU and GPU can help improve performance and reduce power consumption
- Efficient ‘zero-copy’ buffer management is crucial to avoid saturating the limited available SoC bandwidth

Game changing technology available from Imagination

- Imagination’s PowerVR imaging framework for Android provides everything needed to add new OpenCL-based software into a camera application
- Increasing availability in OEM products in 2015

www.imgtec.com/gpucompute

Imagination

Thank You