Reducing SoC Bandwidth Consumption for Performance, Power and Cost Tuning

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PowerVR Product Families

PowerVR GPU and Neural Network Accelerator IP Families

PowerVR

The best solution for embedded graphics, vision and AI

PowerVR GPU

Broad suite of products covering embedded graphics needs across several applications

PowerVR Vision and AI

Dedicated AI, Vision ISP and vision hardware

XE/XM GPU

Focused features
Fillrate/mm^2
Performance/mm^2

XT GPU

Feature rich
Performance/mW

GP-GPU

Compute focussed solution

3NX NNA

Hardware NN

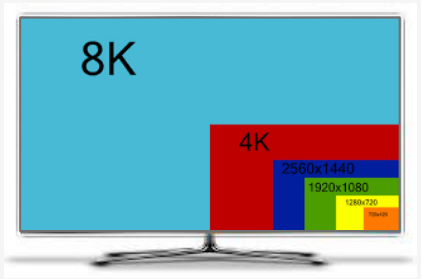
Performance/mm^2
Performance/mW

Vision / ISP

Hardware

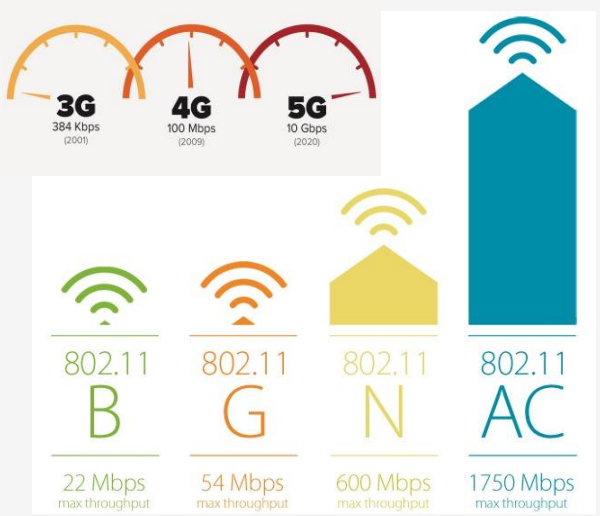
Performance/mm2
Performance/mW

SoC Trends

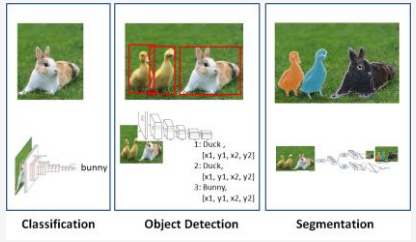


Higher Resolution
Higher Frame Rate
HDR
More Displays

More Sensors
Higher Resolution
HDR
Higher Frame Rate



Faster Data Rates
Multi Channel
Concurrent

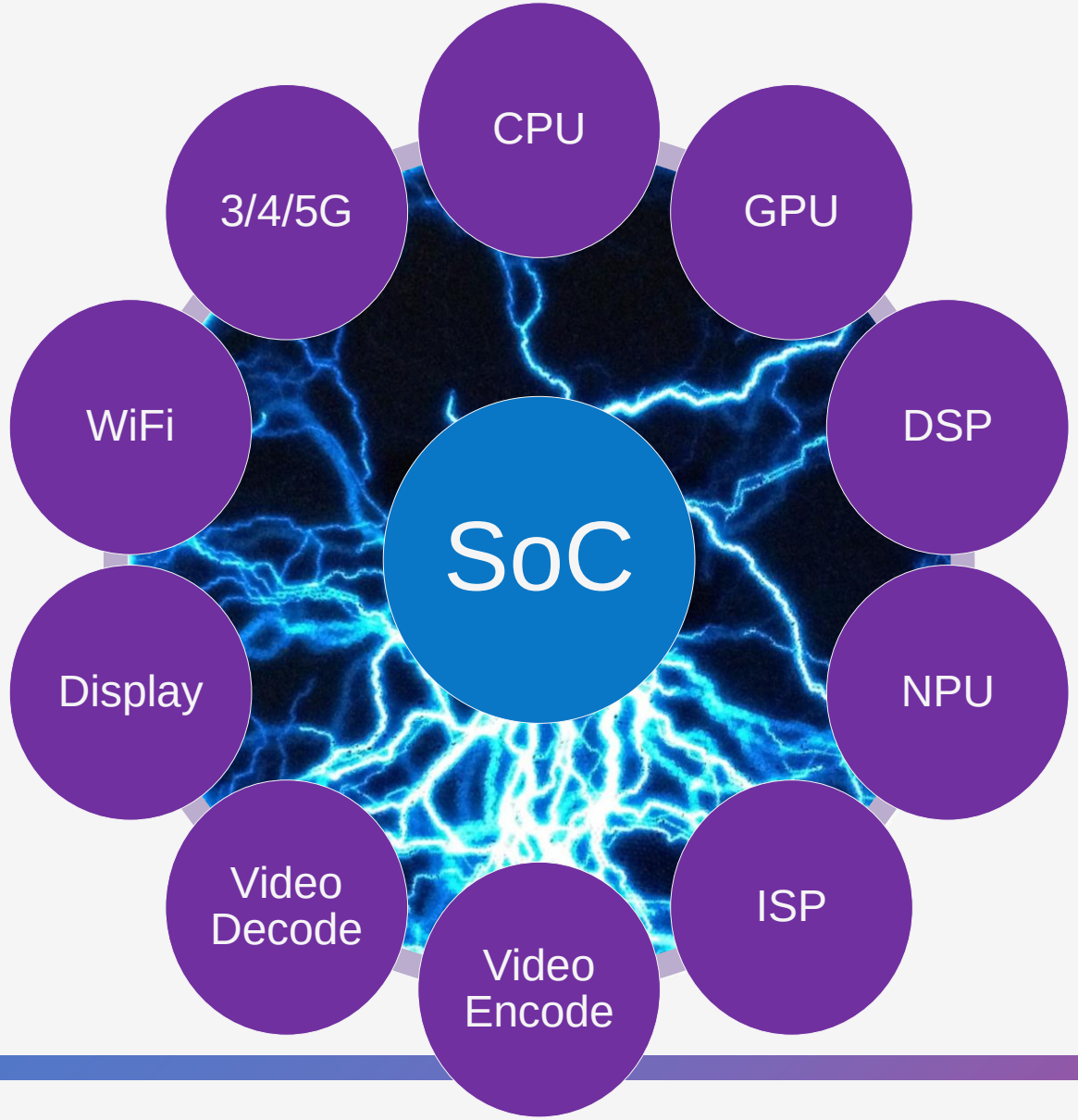


New Processors
Neural Networks

Cost Pressure
Profit Margins

Almost always more, for less…
More functionality, more performance
But always lower cost and lower power

SoC Bandwidth and Memory Footprint Problem



Modern SoC have many IP components

Many work on image/visual data

All use significant bandwidth and memory

Bandwidth consumes power

System memory costs evolve with:

- Number of Interfaces e.g. 1, 2 or 4
- Width of Interface e.g. 16 or 32 bits
- Speed e.g. MHz
- Size of Memory ICs e.g. 1/2/4 GB

How do we reduce this $ and power cost with minimal impact on user experience ?

PowerVR 3C Compression Technologies

PowerVR's comprehensive solution

Reduced memory bandwidth and memory footprint

Minimised system power consumption

Reduced platform costs

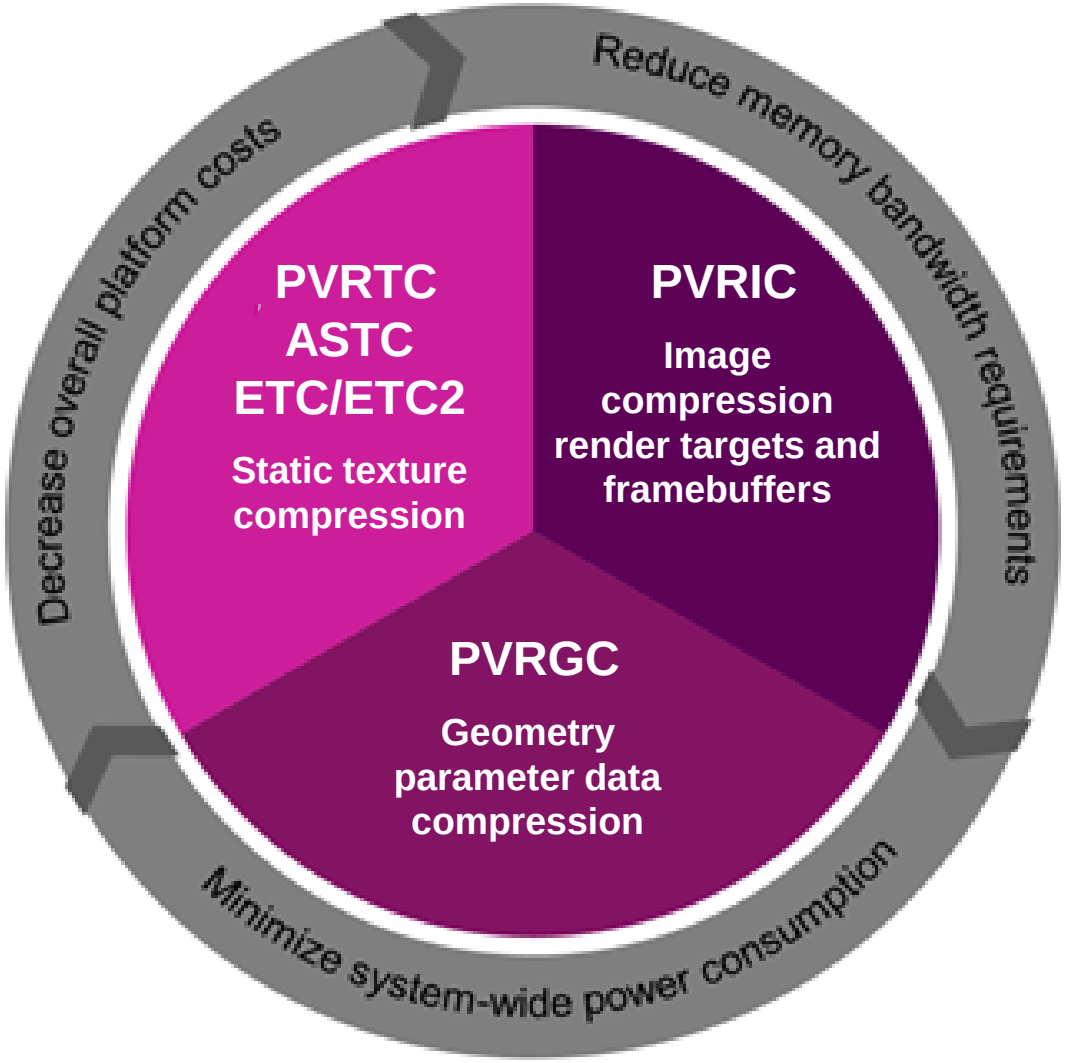
Implemented through three technologies

PVRIC – Frame Buffer Image Compression

PVRTC – Texture Compression

PVRGC – Geometry Compression

In-depth focus on PVRIC in this session



PVRTC – Texture Compression – GPU Only

Developer creates a texture

Compressed texture loaded into CPU memory from disc by application

Developer compresses texture with PVRTexTool * into ETC, PVRTC or ASTC format

Application uses API calls to submit texture to GPU

GPU

Reads texture

Decompresses

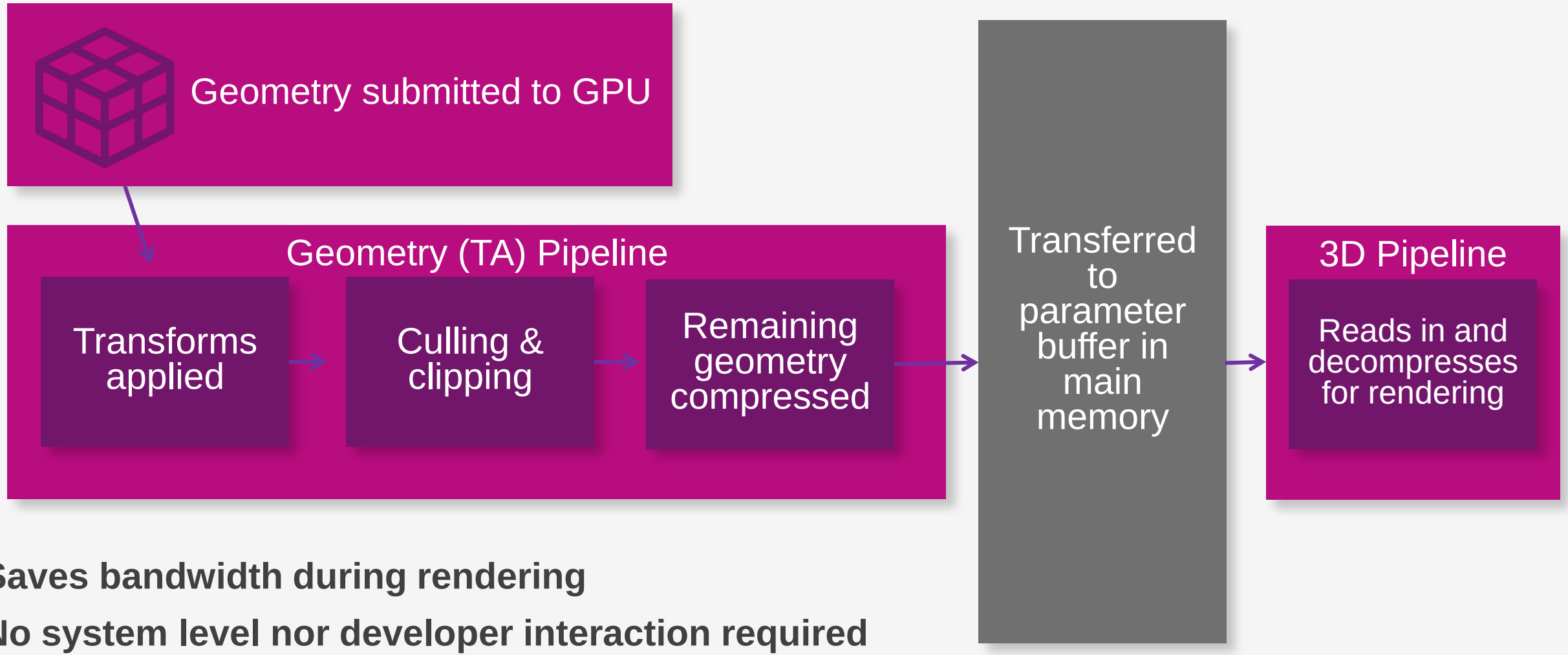
Uses decompressed texture for rendering

Saves bandwidth during rendering

Saves system storage for applications

*** Available as part of PowerVR SDK**

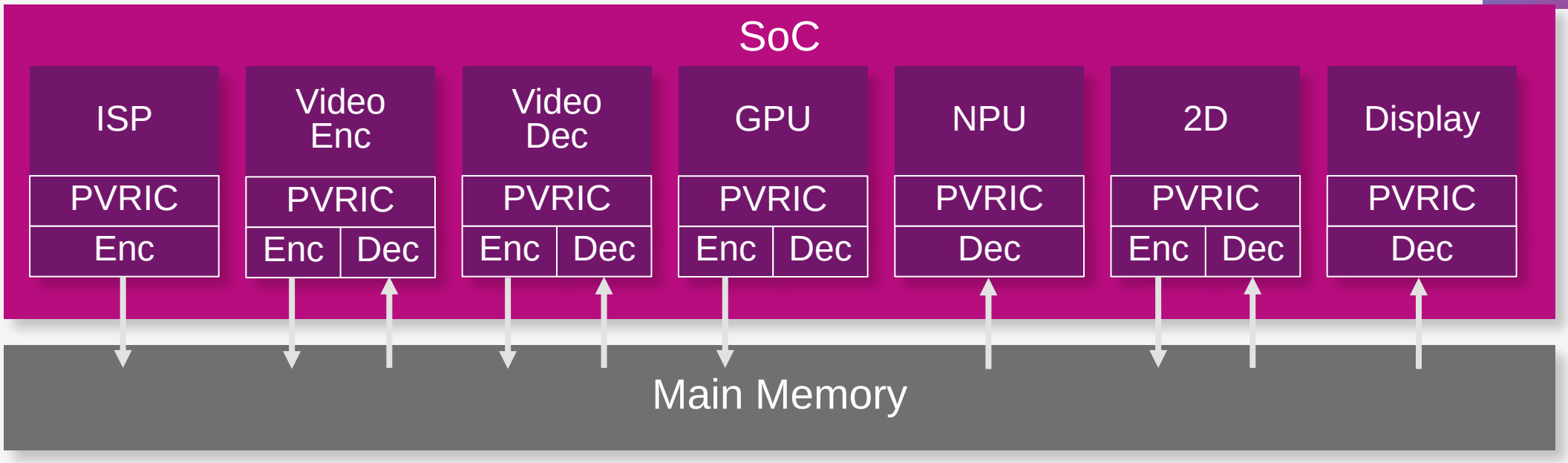
PVRGC - Geometry Compression – GPU Only



Saves bandwidth during rendering

No system level nor developer interaction required

PVRIC – Image Compression – Generic Benefit



PowerVR Image Compression across wide range of RGB/RGBA and multi-planar YUV formats

High speed random data access with full Read/Modify/Write capabilities and low latency

Many blocks require encoding/decoding capabilities (read/write) some only read or write

Widely implemented by Imagination's IP customers already – proven implementations

Partnerships with other IP providers such as Chips&Media (Video and other IP solutions)

Introducing PVRIC Visually Lossless Compression

Guaranteed 2:1 Compression Ratio for Reduced Memory Footprint and Bandwidth

Before: PVRIC3 and earlier = Lossless Compression Only

No guarantee on bandwidth reduction so no guaranteed power/footprint/cost benefit

Today: PVRIC4 = Visually Lossless + Lossless Compression Modes

Guaranteed minimum 2:1 compression ratio

- ✓ Half or less bandwidth guaranteed – power consumption reduced
- ✓ Half the memory footprint for buffers (fixed) – memory consumption/cost reduced
- ✓ Improvements in memory access efficiency (burst sizes)

Perceptually lossless

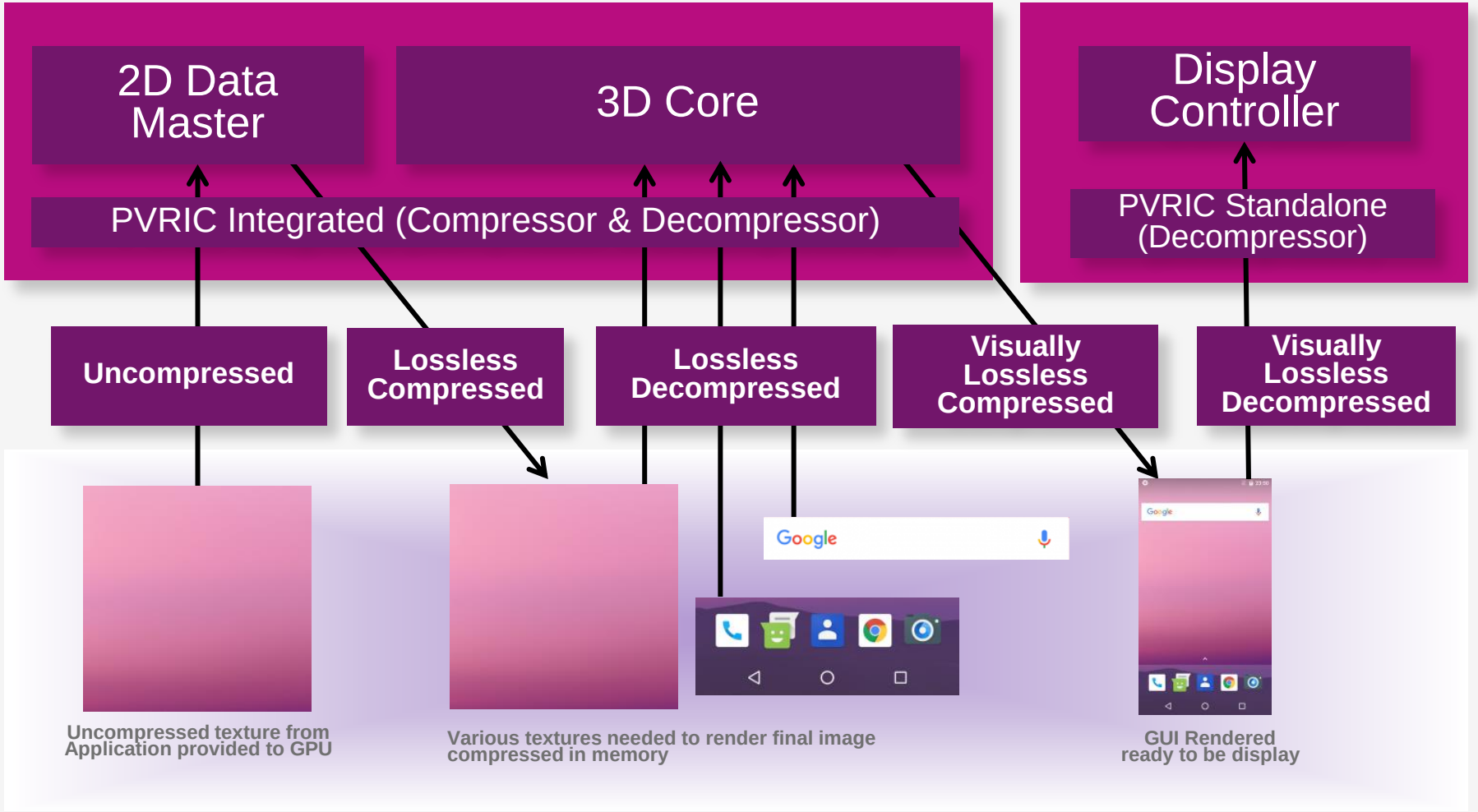
- ✓ Use lossless compression mode for blocks where possible – zero quality impact
- ✓ Use high quality lossy compression fallback only when lossless compression is not 2:1 or better

Supported for most popular framebuffer image formats including RGBA (8888) and YUV

Random access with full Read/Modify/Write capabilities

PVRIC4 (Visually Lossless) Compression

PowerVR GPU Usage Example



PVRIC4 Dual Pipeline

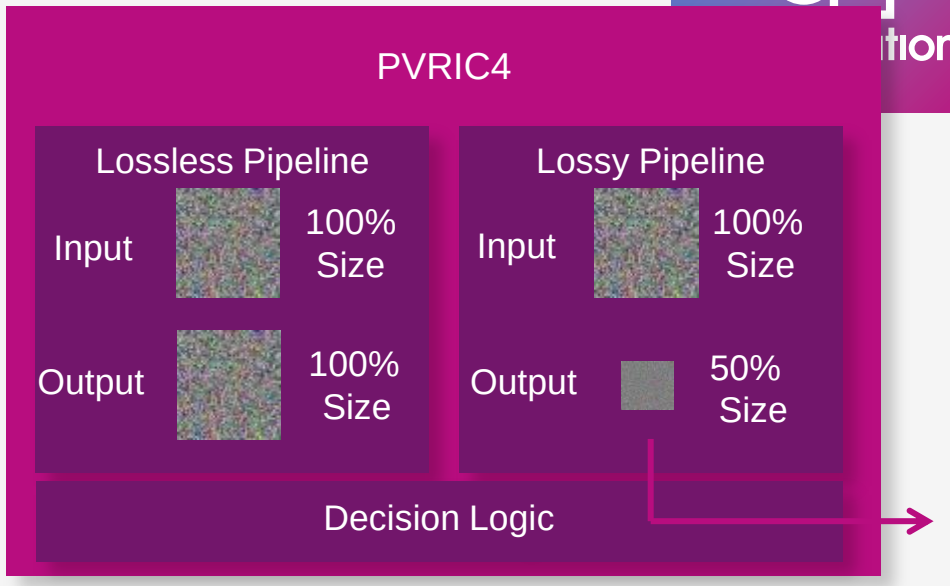
When a block is input to PVRIC4:

Block is compressed in both lossy and lossless pipelines

Decision logic decides which block to use

If lossless is less than 50% original size then this is selected

If lossless cannot achieve 50% then lossy is selected

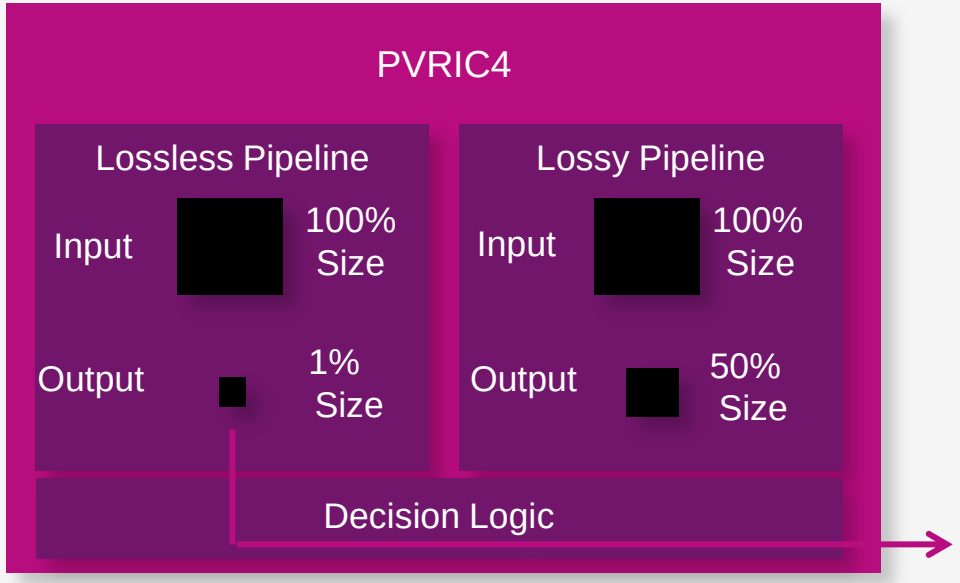


This guarantees each block will be compressed by at least 50%

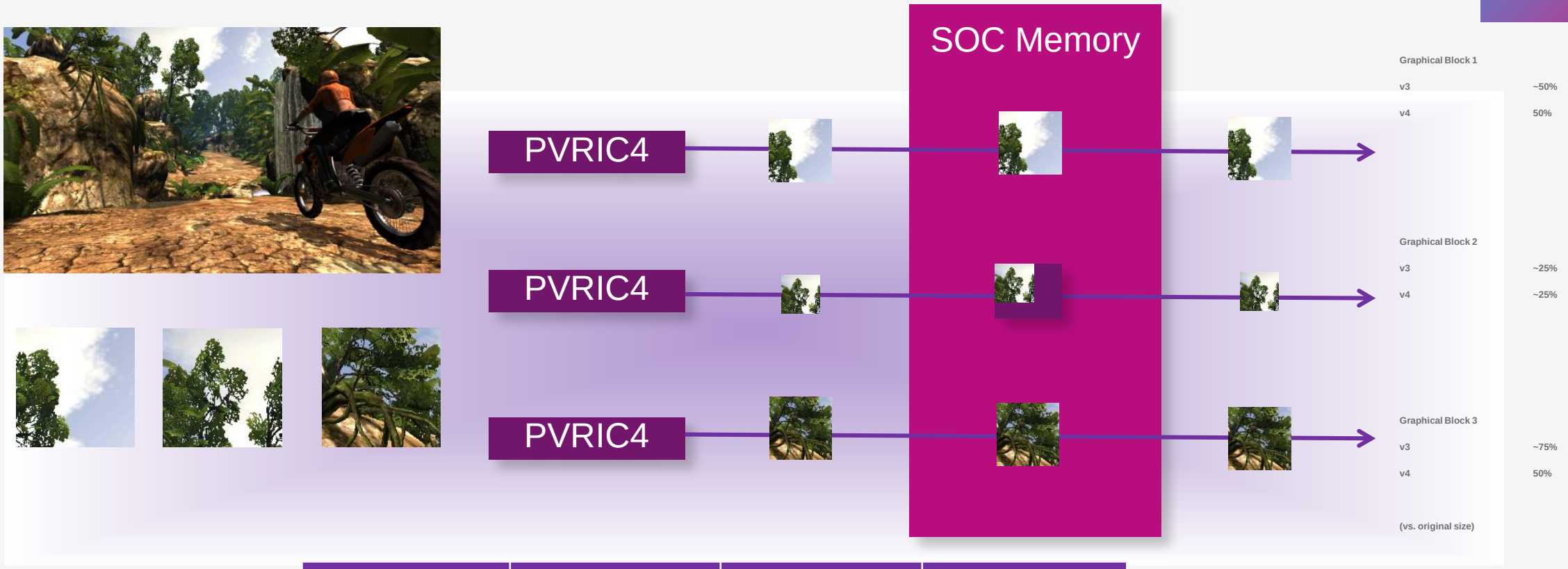
Guaranteed reduced bandwidth and memory footprint

Controlled by hardware so no control needed by SOC vendor

Lossy can be disabled using software controls



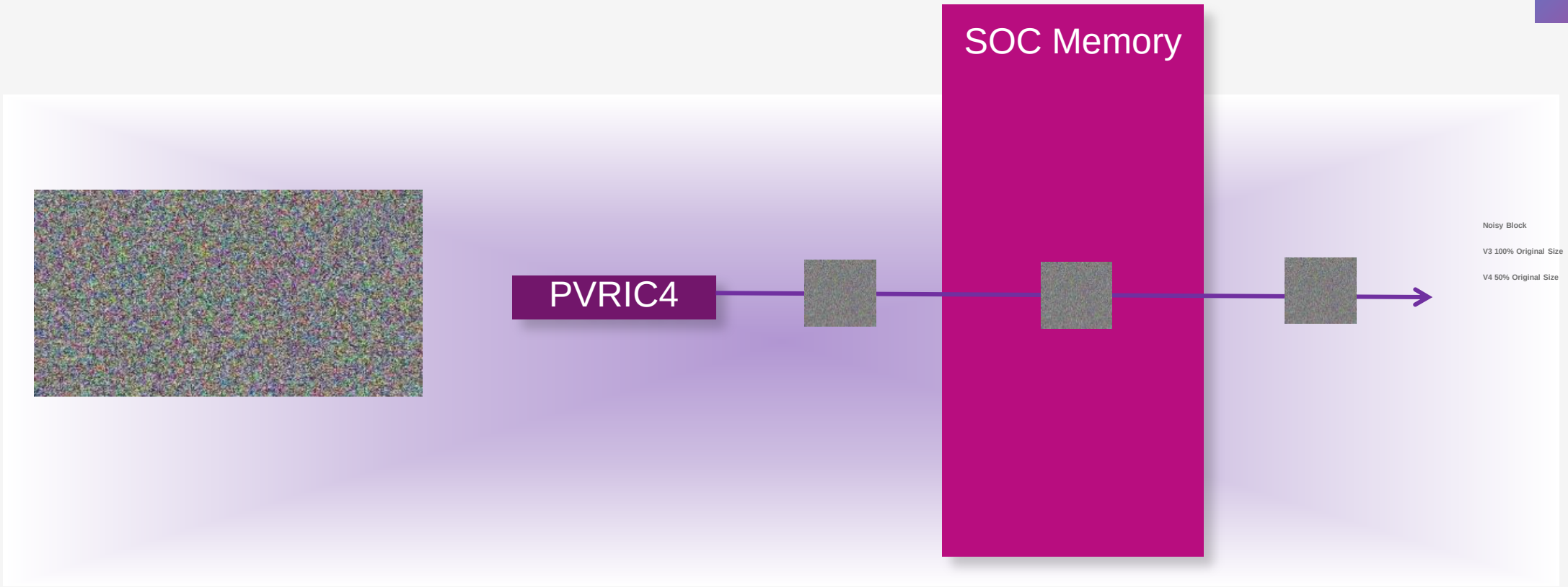
PVRIC4 Lossless + Visually Lossless Modes



PVRIC4 Block	Graphical 1	Graphical 2	Graphical 3
Bandwidth v3	128Bytes	64Bytes	192Bytes
Bandwidth v4	128Bytes	64Bytes	128Bytes
Mem Size v3	256Bytes	256Bytes	256Bytes
Mem Size v4	128Bytes	128Bytes	128Bytes

Lower is better

PVRIC4 Now Compresses All Content



Noise, worst case for lossless compression – no data correlation

Visually Lossless compression to guarantee 50% bandwidth/footprint

Guaranteed SoC bandwidth and cost reductions

Block Size	PVRIC3	PVRIC4
Bandwidth	256Bytes	128Bytes
Size in Memory	256Bytes	128Bytes

Lower is better

PVRIC4 Visually Lossless Compression

On a per frame basis

Some blocks stored lossless (Black on right)

Some blocks stored lossy (Purple on right)

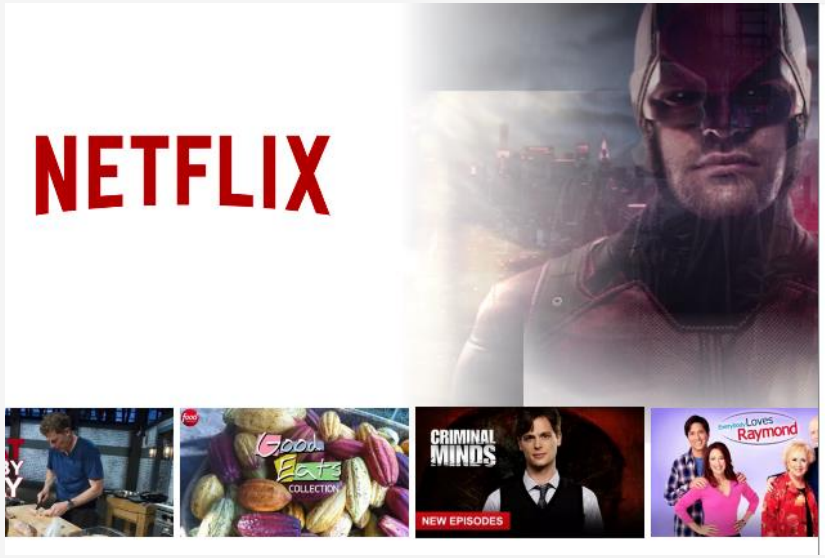
Image quality change is minimal

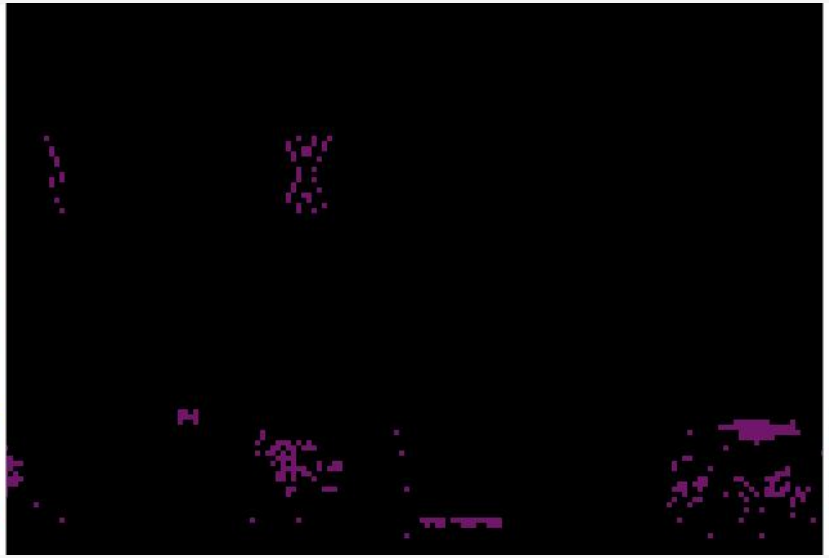
Algorithms are tuned to avoid halos or artifacts

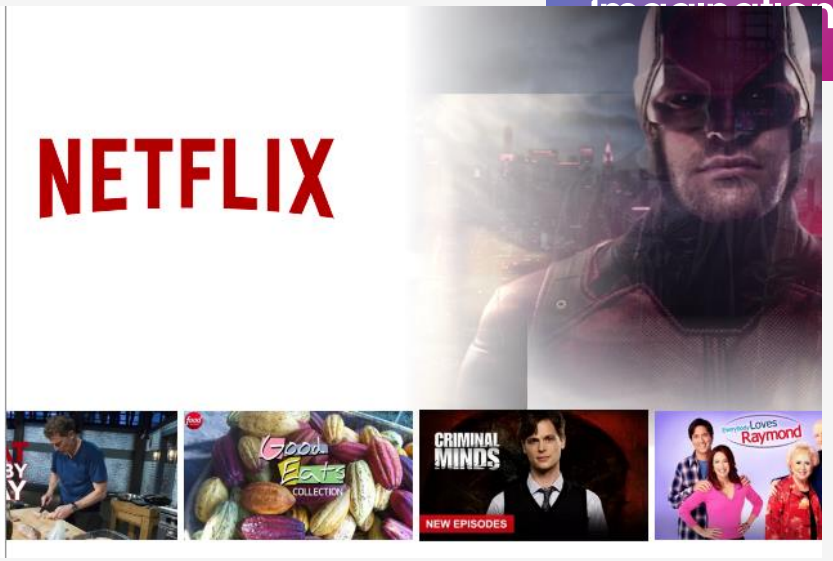
Minor changes to individual pixel values

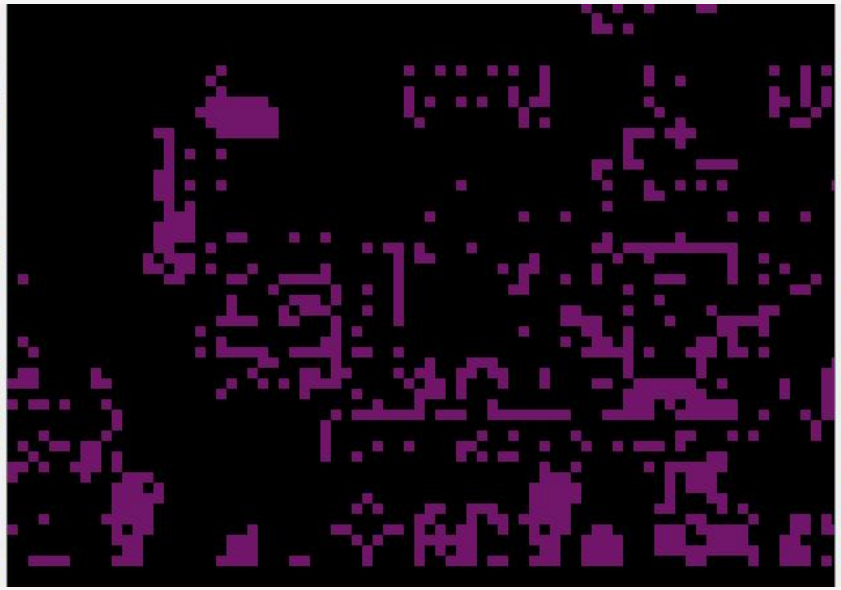
Localised to small detailed blocks in the image

Quality Examples – Netflix GUI & Angry Birds





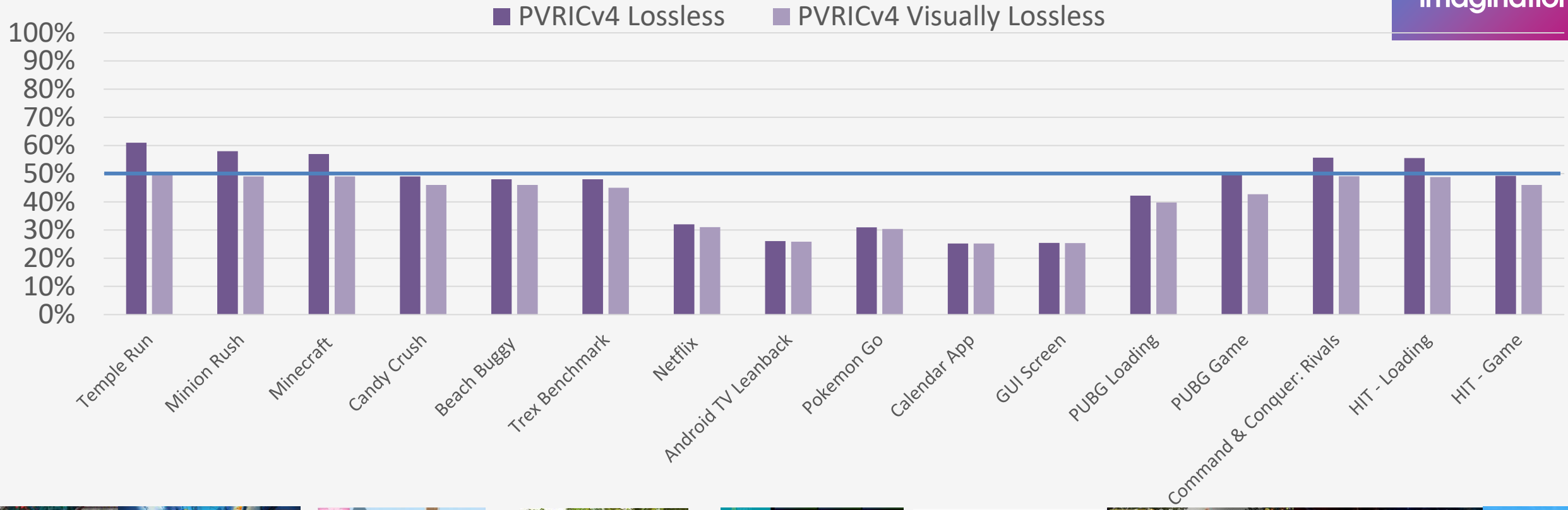


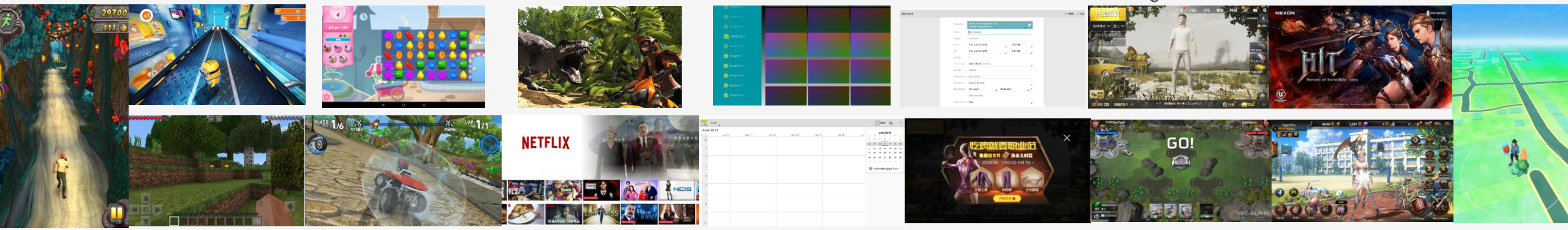


Spot the difference – Spot the original ?

Game and YUV Video Content – 16x zoom – no obvious artifacts (ringing, sparkles, mismatched colours)
Without side by side and labels which image is “uncompressed” ?

PowerVR PVRIC4 Compression Stats





Summary

SoC bandwidth and memory requirements continue to increase

Low cost markets need to keep memory/bandwidth cost in check

Premium markets need to keep power consumption under control

PVRIC4 helps reduce Image bandwidth and memory footprint

Guaranteed 2:1 or better reduction in bandwidth and associated power consumption

Guaranteed fixed 50% memory footprint reduction

Stand-alone IP – Encoder/Decoder available for eval and licensing now

Soft IP, process technology independent, flexible integration, range of performance points

Integrated in all PowerVR 2018 GPU releases – public details in December

Imagination

Thank you

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