Introducing a New Wave of Arm Display Solutions for HDR and VR

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Agenda

• Introduction to the new Arm® Display Solution
• Arm Mali™-D71 architecture review
• Managing HDR Content with Arm Assertive Display 5
• Arm Display Solution Software
• Arm Display Ecosystem
• Summary
Mobile Display Disruptive Trends

VR

Panel Variety

HDR

Multi-Window
Arm Display Solution

Feature Rich:
- Composition, Scaling, Rotation, Gamma & Colour/Gamut management, Ambient Light Adaptivity, Advanced HDR management, Dual Display

Low power real-time performance
- Single pass composition, Arm Frame Buffer Compression (AFBC), Optimized MMU-600 integration, Backlight Power Saving

Optimized software support:
- Android DDK
- Linux KMS
- Arm Mali Multimedia Suite

Supports all major display industry standards:
- MIPI, HDMI, VESA, CEA-861, ITU-R
Arm Mali-D71 Display Processor
Delivering 4K120 Performance for Next Generation Premium Devices

- 30% System power saving*
- 2x Area efficiency**
- 4x Latency tolerance**
- 2x Pixel throughput**

*Compared to the same task on GPU SW / **Compared to Mali-DP650
Arm Mali-D71 + Arm CoreLink MMU-600

Simpler Integration and Smaller Area Compared to Previous Generations

- Area saving: 55%
- Latency reduction: 50%
Arm Assertive Display 5
High Quality HDR Viewing Experience on all Displays and under all Light Conditions

Assertive Display 5 Off

Assertive Display 5 On
Arm Mali-D71
Architecture Review
Arm Mali-D71 Overview
Layer Processing Unit

LPU designed to prevent underrun for even the most aggressive 4K and orthogonal rotation use cases

- Memory Subsystem
- Latency Buffers Subsystem
- AFBC Decoder Subsystem
- Layer Pipelines Subsystem
AFBC Encoder Unit enables efficient orthogonal rotation of uncompressed display layers

- Linear to block format conversion and compression
- Memory to memory operation
- More efficient MMU cache and DRAM memory access pattern
- Better system performance and improved display underrun robustness
Composition Unit

Composition Subsystem

- Alpha-blends up to 8 layers
  - up to 4 video layers

Scaling Subsystem

- 4 High-quality Scaling Engines
- 12-bit per component precision
- Image enhancer with edge detection
- Simultaneous scaling before and after composition
Display Output Unit

Display Output Unit (DOU)

- Image Processing subsystem
- Backend subsystem

CU layer
- Gamma, Dither, RGB2YCbCr
- Line Split, YCbCr 4:2:0
- Frame Timing, CMode

DOU 0

Link 0
- Gamma, Dither, RGB2YCbCr
- Line Split, YCbCr 4:2:0
- Frame Timing, CMode

Link 1
- Side-by-Side Split

Backend Subsystem

1:2 Display Split

DISPLAY OUTPUT LINK 0

Display Output Unit (DOU)

- Gamma, Dither, RGB2YCbCr
- Line Split, YCbCr 4:2:0
- Frame Timing, CMode

DOU 0

Link 0
- Gamma, Dither, RGB2YCbCr
- Line Split, YCbCr 4:2:0
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Link 1
- Side-by-Side Split

1:2 Display Split

DISPLAY OUTPUT LINK 1
Better Android Window Composition Capabilities

Support for multi-window sessions in Android N

- Optimized HWC Solver

8 composition layers when driving a single display

- 4 layers per display output for dual display

4 scaled layers when driving a single display

- 2 scaled layers per display output when driving a dual display

Simultaneous layer + pixel alpha blending

- Ideal for window animations

Fully flexible and software programmable Z order
Flexible use of Display Processor Resources

Software Layer Split and Layer Merge
Software layer split and internal layer split of display layers with 2 scaling engines to optimize demanding downscaling use cases

Side by Side Processing
Side-by-side processing for low voltage operation at 4Kp60-120fps
Composition Data Flow – Single Display

Uncompressed to AFBC

Write back

Dual link mode

8x Alpha blended layers

4K60
Composition Data Flow – Dual Display

Uncompressed to AFBC

Write back

Write back

Dual link mode

4x Alpha blended layers
4K60

Dual link mode

4x Alpha blended layers
4K60
Composition Data Flow – Side-by-side

Uncompressed to AFBC AFBC for Orthogonal

Write back

Write back

4x Alpha blended layers 4K120
Improved Performance in the Multimedia System

Optimized DPU Memory Subsystem

Increased read OT capability

Embedded MMU TBU with TLB prefetch mechanism in each LPU

SMMU strategy based on Arm CoreLink MMU-600

Orthogonal rotation of uncompressed layers taken out from the real-time path

Application Note Available upon request
Managing HDR Content with Arm Assertive Display 5
Assertive Display – Perfect Outdoor Viewability

Assertive Display maintains the viewing experience under any viewing condition.

Iridix local tone mapping engine preserves the Textures, Dark details, Highlights, Contrast and Color with Assertive Display.
Assertive Display – Power Saving

Viewability Preserved Even at Dimmed Backlight/Brightness

No Assertive Display

- 100% screen brightness

Assertive Display

- 100% screen brightness

- 25% screen brightness
HDR Content and Display

- HDR content has MUCH higher dynamic range (DR)
- 8-bit sRGB was about 2000:1 DR, now it is about 100000:1
- HDR capable displays have different brightness and black reproduction, therefore different DR even in a dark room
- Ambient light is affecting the display’s DR even stronger
- HDR content will have wider colour gamut (BT.2020)
- Assertive Display 5 offers a complete HDR solution
Assertive Display 5 – Key Features

HDR management
- Mapping the DR of the content to the DR of the display using high precision iridix8-HDR® Local Tone Mapping
- Automated HDR experience on SDR display

Gamut/Color and Gamma management
- Mapping the gamut of the content to the gamut of the display using a compact 3D-LUT (soft-clipping to preserve textures)
- Gamma response and peak brightness of the panel

Ambient light adaptivity and Power saving for both HDR and SDR flow
- HDR content suffers more from high illumination/reflections and dimmed backlight/brightness

Color Enhancer 3D-LUT (optional)
- Programmable color profiles to achieve more vivid and natural colors using a silicon-efficient 3D-LUT

HDR10, PQ and HLG support

Blue light filtering implemented in Hardware
Assertive Display 5 – Architecture

**Arm Mali-D71**

- HDR/SDR content
  - Rec.2020-P3-709
  - RGB high precision
- Ambient light
- Backlight
- Content info
- Display info

**Assertive Display 5**

- HDR transfer characteristic management
- Content gamma management
- Gamut/color mapping
- PIP-ROI management
- iridix8-HDR local tone-mapping engine
- HDR automated re-mastering
- Ambient light adaptivity
- Backlight management and power saving
  - content-adaptive
  - content-independent
- Display gamma management
- Color enhancer (optional)

**HDR/SDR content**
- Rec.709-P3-2020
- RGB high precision

**Backlight**
Assertive Display 5 – HDR Management

HDR10 Content on a Standard Display Without Tone Mapping
Assertive Display 5 – HDR Management

...With Global Tone Mapping (Loss of Highlights, Color Saturation and Contrast)
Assertive Display 5 – HDR Management

...With Assertive Display 5 Local Tone Mapping
Assertive Display 5 – 3D-LUT Soft-clipping Color Conversion

Rec.2020 Converted to Rec.709 via Color Conversion Matrix Based Hard-Clipping
Assertive Display 5 – 3D-LUT Soft-clipping Color Conversion

Rec.2020 Converted to Rec.709 via 3D-LUT Based Soft-Clipping
HDR Composition

Arm Mali-D71 + Arm Assertive Display 5 as the first HDR solution from Arm

Mixed HDR/SDR content handling and composition in Arm Mali-D71

Gamut and Colour management in Assertive Display 5

Arm Assertive Display 5 seamlessly integrates with Mali-D71 using coprocessor interface
Mixed HDR/SDR Composition for any Display

Mixed Content Use cases
- Full screen HDR video playback
- Full screen HDR video with SDR UI/controls
- HDR video picture-in-picture with SDR background layer
- HDR video picture-in-picture with SDR UI and SDR background layer

SDR display
- Gamma 2.2/2.4
- Peak brightness < 400 nits
- Rec.709 Colour gamut

HDR display
- Gamma 2.2/2.4
- Peak brightness OLED > 600 nits, LCD > 1000 nits
- DCI-P3 or Rec.2020 Colour Gamut
Display Solution Software
Android Media Subsystem Overview
Arm Display Solutions: Android Software Stack
For Arm Mali-D71 and Assertive Display 5
Display Ecosystem
Arm Mali Display Ecosystem

Arm Mali Display team work closely with major display PHY, DDIC & panel vendors to provide complete and optimized solutions.

Arm Mali Display team works with various companies & standards bodies to enable better AR/VR experiences and to reduce the complexities of porting & integration.
Today’s Premium Smartphone

Smartphone Application – WQHD+

**Step 1**
WQHD 1440x2880 /60Hz/24bpp
1 stream at ~6.3 Gbps

**Step 2**
2:1 compression
1 stream at 3.16 Gbps

**Step 3**
DSI Port has 4 data lanes @ 1Gbps
Total bandwidth is 4Gbps

Mali-D71 Display

Arm Application processor

WQHD+ is 270 Mhz pixel clock
Future Premium Smartphone

Smartphone VR Application – 4K+

**Step 1**
4320x2160 /90Hz/30bpp
1 stream at ~26.6 Gbps

**Step 2**
2 streams at ~13.3 Gbps

**Step 3**
3:1 compression
2 streams at ~4.44Gbps

**Step 4**
DSI Port has 4 data lanes @ 1.5Gbps

**Ecosystem**

- MIPI DSI Host Controller
  - VESA DSC v1.1 Encoder
  - MIPI DSI Host Controller v1.2
  - MIPI D-PHY V1.2

**Display Driver**
4 data lanes 1 clock lane

**2160x4320p90**

Ecosystem

| 454 Mhz pixel clock |

Display Driver

Same CLK for both DPhys to avoid drift

**Embeded Display Ecosystem**
Summary
Arm Display Solution 2017
New Functionality Versus 2016

8 composition layers (vs 4 in DP650), Side-by-side, Scaling split

Uncompressed rotation removed from the real time path, Higher AFBC decoder throughput

Guaranteed performance and underrun robustness thanks to new MMU-600 strategy

HDR10 video playback support with mixed HDR/SDR content handling

Iridix8-HDR management, Advanced Gamut and Colour Management, Blue light filtering implemented in hardware
Arm Display Solutions

A single Display solution based on a brand new architecture, Komeda, addressing recent display technology disruptors

Mali-D71 and Assertive Display 5 deliver an optimal HDR-10 viewing experience to any HDR or SDR mobile panel under any light conditions

Mali-D71 and CoreLink MMU-600 deliver lowest power display performance up to 4K120 for premium, VR capable mobile displays

Delivering the ultimate viewing experience whilst increasing device performance
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