ARM Multimedia Roadmap Update

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The increasing pace of technology

2010
- Smartphones ‘must have’ device
- Online features/functionality expanding
- ~300 million smartphones sold *
- Explosion in Apps

2016
- Smartphones everywhere
- Always connected population
- ~1,400 million smartphones sold *
- Virtual Reality starts blending real and technical worlds

2021
- Smartphones centre of our digital lives
- Broad range of devices ‘around’ the smartphone
- ~1,800 million smartphones sold *
- Real and technical worlds merged
- Efficiency, scale and performance from mobile technology means it’s used everywhere

*statista.com
Computing and graphics are everywhere

#1 shipping GPU in the world is Mali

5.5Bn ARM-based embedded chips shipped in 2015

> 5Bn people using ARM-based mobile phones

25Bn ARM-based chips shipped in 2 years
Advances to meet consumer’s expectations

Today’s high-end phone compared to 2009

300x Higher GPU performance

20x Increase in connectivity

24x Higher screen resolution

100x Higher compute performance

5x Increase in environmental sensors
# Doing more with less

## Shrinking form factors

<table>
<thead>
<tr>
<th>Year</th>
<th>Device</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>HTC Nexus One</td>
<td>11.5</td>
</tr>
<tr>
<td>2012</td>
<td>Galaxy S3</td>
<td>8.6</td>
</tr>
<tr>
<td>2014</td>
<td>Lumia 1520</td>
<td>8.4</td>
</tr>
<tr>
<td>2016</td>
<td>Mate 8</td>
<td>7.9</td>
</tr>
</tbody>
</table>

## More processing

- HTC Nexus One: 11.5mm
- Galaxy S3: 8.6mm
- Lumia 1520: 8.4mm
- Mate 8: 7.9mm

## More challenging heat dissipation

Increasing demand for more efficient compute

## New features

- 45% thinner since 2010
Consumers expect compelling user experiences across all devices

- ARM-based SoC enable these new experiences

>90% of automotive infotainment systems are ARM-based

>90% home UHD devices are ARM-based
User experience over benchmarks

User Interface
- High resolution
- Many layers
- Power efficiency critical

Gaming and Apps
- More complex geometry
- More complex texturing
- More complex graphics techniques (sprites, spectral effects, particles)

High End Content (e.g. VR)
- Very high resolution
- Multiple screens (e.g. VR)
- Very complex geometry
- Very complex texturing
- Super low latency
Enlighten delivers high quality, immersive VR experiences

- **Why is dynamic Global Illumination (GI) important in VR?**
  - High quality lighting is critical to an immersive experience & storytelling
  - Bad lighting is highly evident in VR and detracts from immersion

- **VR challenges and requirement**
  - Very high frame rate and resolution
  - One view per eye and low latency
  - **VR places an extreme load on the GPU**

- **Enlighten asynchronous technique does not affect frame rate**
  - Compute once, render twice
  - Consistent results with no screen-space artefacts
  - Light Based Culling – lighting can be tuned to rendering budget
The industry’s most advanced GI technology

Enlighten benefits:

- High scalability
- Physically based dynamic lighting
- Differentiated gameplay
- Rapid iteration time
- High quality results
- Ability to bake light maps if desired
Licensed by top studios for leading titles

- EA DICE – Star Wars Battlefront
- Blizzard Entertainment – Overwatch
- EA BioWare – Dragon Age Inquisition
- Capcom – Street Fighter V
- Square Enix – Final Fantasy VII Remake
- Ninja Theory – Hellblade
- CCP – EVE Online
- Deck 13 – Lords of the Fallen
- Perfect World – upcoming mobile title
- Exient – upcoming mobile title
Even the smallest use cases are demanding more

Connected intelligence in the fabric of our lives

Heart rate: 166 bpm
Skin temp: 33.5 °C
SpO2: 96%
Speed: 10 km/h
Distance: 0.5 km
Calories per hour: 818
Hydration level: good

Invisible Intelligence
Beyond the wrist with seamless, wearable sensor integration in our everyday lives

Lifestyle
Constantly monitor and adapt our behavior to reduce negative cycles such as stress and fatigue

Health and Wellbeing
Democratizing healthcare for the wider population. Early diagnosis, remote telecare, patient monitoring

Advanced Materials Science
Fully flexible, rugged, washable invisible devices that integrate into our everyday clothing

Always on, Always Connected
Driving a new wave of cloud based health and wellbeing services
New use cases will continue driving demands

Augmented Reality
- Image recognition
- Content overlay
- Merging the Virtual and the Real

Virtual Reality
- Creating immersive environments

Gaming
- Delivering stunning interaction
- Up to 4K Consistent Frame Rate
- 120FPS
- 4K resolution
- Low latency

Virtual Reality

CPU
GPU
VIDEO
DISPLAY
CAMERA
MEMORY

Creating immersive environments

Virtual Reality

Augmented Reality

Gaming
VR Use-cases – Driving System Demand

- Virtual Reality Gaming
  - Interactive high-end graphics

- Virtual Reality Video/360 Video playback
  - Immersive video content
Computer vision ups the game again

Automotive

AR & VR

Video Analytics

Computational Photography
...and filled them in
ARM with Apical has a strong imaging knowledge base…

- Invented what remains the most successful digital model of the retina
- World’s first camera with HDR
- First smartphone with outdoor viewability
- World’s first smartphone with HDR video
- World’s first camera with local tone mapping
- World’s first HDR HD video camera
- World’s first ISP with NLM-based noise reduction
- HiSilicon has major IP camera market share with Apical ISP

Timeline:
- 2002
- 2004
- 2006
- 2008
- 2010
- 2012
- 2014
- 2015
- 2016
Assertive Display

Saves power and allows you to see screens under bright sunlight

Without Assertive Display® in bright sunny condition

With Assertive Display® under same conditions
Camera - Image Signal Processor

- **Features**
  - Lens shading (vignetting) correction (mesh and radial) and Geometric Distortion Correction engine
  - Advanced spatial (2D) noise reduction (sinter®)
  - Motion-adaptive temporal (3D) noise reduction (temper™)
  - Multi-exposure HDR image fusion
  - Space-variant HDR processing (iridix®)

- **Performance**
  - >500Mpixel/sec
  - 1080p60/4K video
  - 256Mpixel sensor support

- **Deliverables**
  - Hardware IP, Firmware, Tuning software and support
Active Picture Capture for HDR

iPhone 6S HDR mode

Active Picture Capture On Google Nexus 6
Computer Vision

- On-device hardware accelerator of vision tasks
  - Capable of detecting an unlimited number of objects in real-time HD video
- High power-efficiency and low Silicon area
  - Suitable for battery-powered, portable devices
- Licensed by multiple SoC vendors for next-generation smart cameras and sensors
ARM Mali GPU advancements achieve more

**BIFROST**
- Mali-G71 GPU
- Unified shader cores, scalar ISA, clause execution, full coherency, Vulkan, OpenCL

**MIDGARD**
- Mali-T600 GPU series
- Mali-T700 GPU series
- Mali-T800 GPU series
- Unified shader cores, SIMD ISA, OpenGL ES 3.x, OpenCL, Vulkan

**UTGARD**
- Mali-400 GPU
- Mali-450 GPU
- Mali-470 GPU
- Separate shader cores, SIMD ISA, OpenGL ES 2.x
Mali-G71 efficiency drives performance

- 20% Higher energy efficiency*
- 32 Shader cores
- 40% Better performance density*
- 20% Bandwidth Improvement*

Optimized for next generation, advanced, real-world content

*Compared to Mali-T880, on same process node under the same conditions.
Mali-G71 provides a next generation experience

- Premium Mobile GPU exceeds Laptop GPU performance
- Outstanding Performance, Power, and Area

2016 Premium Mobile GPU Mali-G71 MP16
2015 Discrete Laptop GPU
2015 Mid-Range Laptop GPU
2015 Premium Mobile GPU Mali-T880 MP12

GFXBench 4.0 1080p Manhattan 3.1 Offscreen

<table>
<thead>
<tr>
<th>Relative Performance</th>
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<tbody>
<tr>
<td>1.00</td>
</tr>
<tr>
<td>0.50</td>
</tr>
<tr>
<td>0.00</td>
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</tbody>
</table>

25w vs 4w
A complete premium mobile experience

1.3x
More performance and efficiency

1.5x
Performance compared to 2016 devices

Compute and graphics performance for the latest and the most demanding use cases
Solutions for all types of devices

**Ultra-Low Power**
- Mali-470
  - 50% power of Mali-400
  - Bringing ES 2.0 to wearable power budgets
- Mali-450
  - Double the performance of Mali-400 MP
- Mali-400
  - First OpenGL ES 2 multi-core GPU
  - Leading area efficiency

**High Area Efficiency**
- Mali-T820 & T830
  - Performance density increases
  - Bandwidth efficiency with ARTC and other features
- Mali-T720
  - Optimised area efficiency and decreased cost and time-to-market
- Mali-T622
  - Enabling Full Profile Compute and OpenGL ES 3.1 in mid-range

**High Performance**
- Mali-G71
  - New Bifrost architecture
  - Designed for Vulkan and VR
  - Scalable to 32 cores
- Mali-T860 & T880
  - Energy efficiency and performance gains
  - UI performance uplift
- Mali-T760
  - Increased SoC energy efficiency
  - Scalability to 16 cores

Smart watch  Smart TV  Clamshell device  Premium phone  Virtual reality
The flexibility to create the ‘right’ solution
Mali Multimedia Suite – better together

- Multimedia products require close integration
- ARM Mali architecture enables consolidated power saving technologies e.g.
  - ARM Frame Buffer Compression (AFBC)
  - Adaptive Scalable Texture Compression (ASTC)
- The Mali family of GPU, Video & Display products are fully integrated and pre-optimized
Mali Multimedia Suite provides a cohesive solution

**Low Memory Bandwidth**
- ARM Frame Buffer Compression (AFBC) for ~35% bandwidth reduction with Mali Video
- Additional ~25% with Mali-Display

**Smallest Area**
- Mali-V500: 1080p60 decode 1.1mm²
- Mali-V550: 1080p60 decode adds HEVC 1.3mm²

**Secure layer with TrustZone support**
- Payment compatible with GlobalPlatform Trusted UI
- Video playback compatible with TrustZone Media Protection

**Integrated Android stack**
- Optimized driver stack for Mali GPU, Video and Display
- Power efficient
- Fast TTM
The best user experiences are built from partnerships

- The richest selection of compelling applications
- Optimized operating systems and platforms
- A secure and power-efficient foundation
- Extensive tooling ecosystem

Apps

OSes

Firmware & power mgmt.

Tools

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谢谢！
Thank you