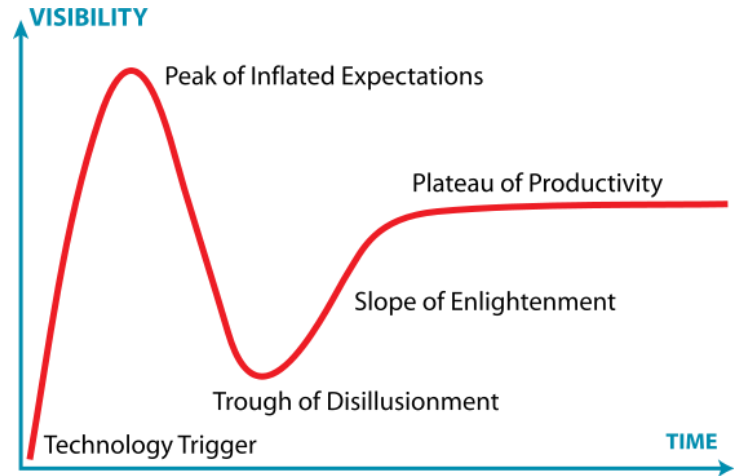# Developing VR Games for Mobile Platforms

ARM

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Graphics Architect, ARM

ARM Game Developer Day - London
03/12/2015

VR today

- Emerging technology

- Main mobile VR ecosystems
  - Google Cardboard
  - Samsung GearVR

- This talk
  - Latency
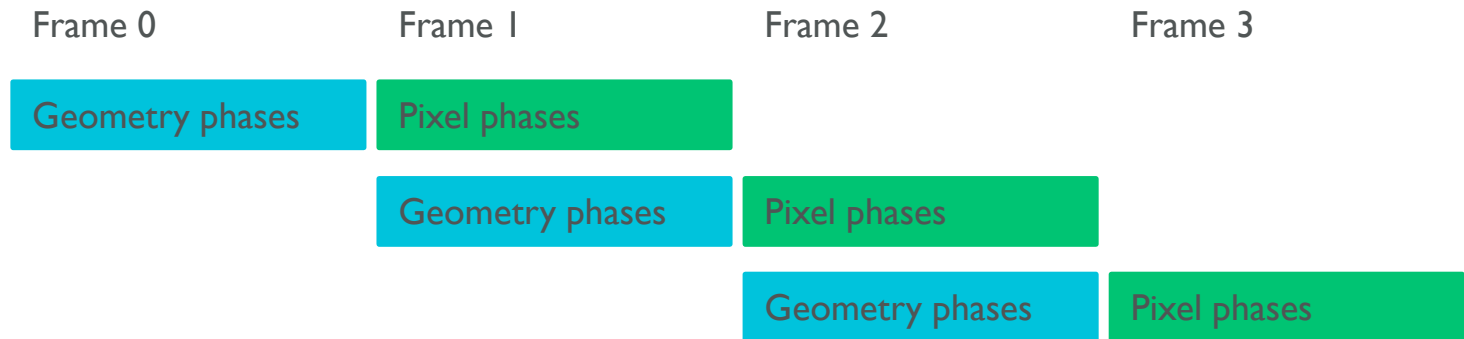 - Multiple views
  - Performance tuning

VISIBILITY

Peak of Inflated Expectations

Plateau of Productivity

Slope of Enlightenment

Trough of Disillusionment

Technology Trigger

TIME

"Gartner Hype Cycle" by Jeremykemp at English Wikipedia. Licensed under CC BY-SA 3.0 via Commons

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Latency

Latency

- "Motion to photons"
  - Target to be imperceptible: 20 ms (GearVR < 20 ms)
  - Ideally below this

- GPUs are <u>throughput processors</u>

- Usually ok to increase latency if it improves throughput…

- Android can/may triple buffer
- Graphics pipeline spread over multiple frames

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Frame Pipelining

Frame 0	Frame 1	Frame 2	Frame 3

Geometry phases

Pixel phases

Geometry phases

Pixel phases

Geometry phases

Pixel phases

- Increases latency, but also increase throughput
- Vertex work typically bandwidth bound – low ALU / load-store ratio

- Overlapping with pixel work increases utilisation

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Recap of VR Pipeline

- Rendering to eye buffer

- Warped to display buffer
  - Lens magnification distortion
  - Chromatic aberration
  - Some redundant panel area

- Eye buffer one of several sources
  - UI
  - Video

Eye buffer – 2048x1024
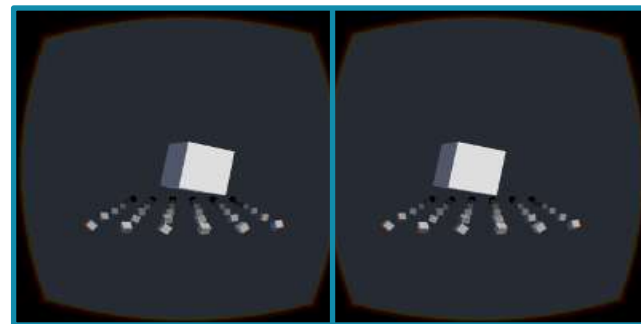
Display buffer – 2560x1440

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Front Buffer Rendering

- GearVR-specific extension

- Remove swap buffers, write to display frontbuffer
- Write to it "just in time"

- Low-persistence OLED display panels
  - Panel only partial illuminated as scanned out
  - Minimises blurring/smearing
  - 60hz refresh rate

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Scan start Scan half way Scan end Loop to scan start here

V Blank

Direction of scan →

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Asynchronous Time Warp

- High and regular priority contexts
  - Application - regular priority
  - Time warp - pre-emptive high priority

- Decouples application and time warp rendering

- Can't account for changes in occlusion
  - Animation
  - Camera motion
  - Near-eye objects

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Multiple Views

Multiple Views

- Options
  - Submit everything twice
  - Geometry shaders
  - Multiview extensions: `OVR_multiview`, `OVR_multiview2`

- Multiview
  - Coming soon…
  - Vertex shader: `uint gl_ViewID_OVR`
  - `gl_Position`-only unless OVR_multiview2
  - Mali supports both
  - Inset rendering: num_views can be > 2!

- Disallows:
  - Transform feedback
  - Tessellation
  - Geometry shader
  - Timer queries

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Mali Multiview Implementation

- Roughly
  - 1 x   CPU submission cost
  - 1-1.5 x   Vertex cost
  - 1 x   Fragment cost

- Saves CPU time on all implementations
- Common vertex processing done once on Mali
  - Using view-dependent parameters will undo this

- Will reduce power / save energy
- May not affect performance unless vertex processing is a bottleneck

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Mali VR SDK

- http://malideveloper.arm.com/resources/sdks/mali-vr-sdk/
- Sample code, documentation

- Introduces the concepts of stereoscopic vision
  - Fundamentals, calibration, correcting lens effects
- Multiview example

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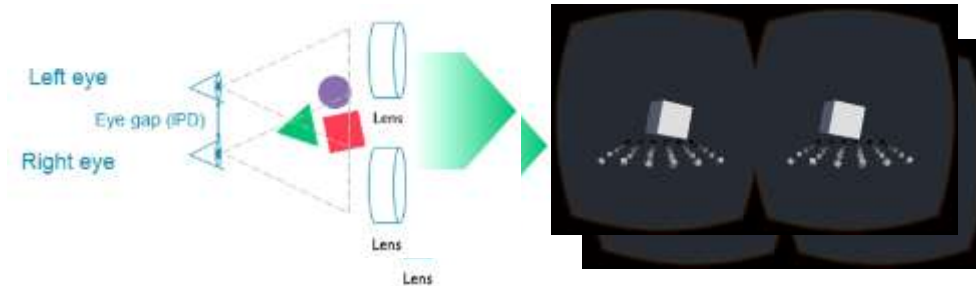
Performance Tuning

Clock Locking

- For stability
- Also saves power, but not as much as reducing work

- Consider clocking as low as possible

- Beware of over-loading the CPUs
  - Use multiple threads

- Keep work off SCHED_FIFO if it's not critical path

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Bandwidth / Quality

- Large consumer of power on high end systems

- Geometry
  - Usual advice: Cull / reduce where acceptable
  - Varyings/interpolants   - reducing precision can help

- Images
  - ASTC
  - AFBC (automatic)

- 4x MSAA close to "free" on Mali
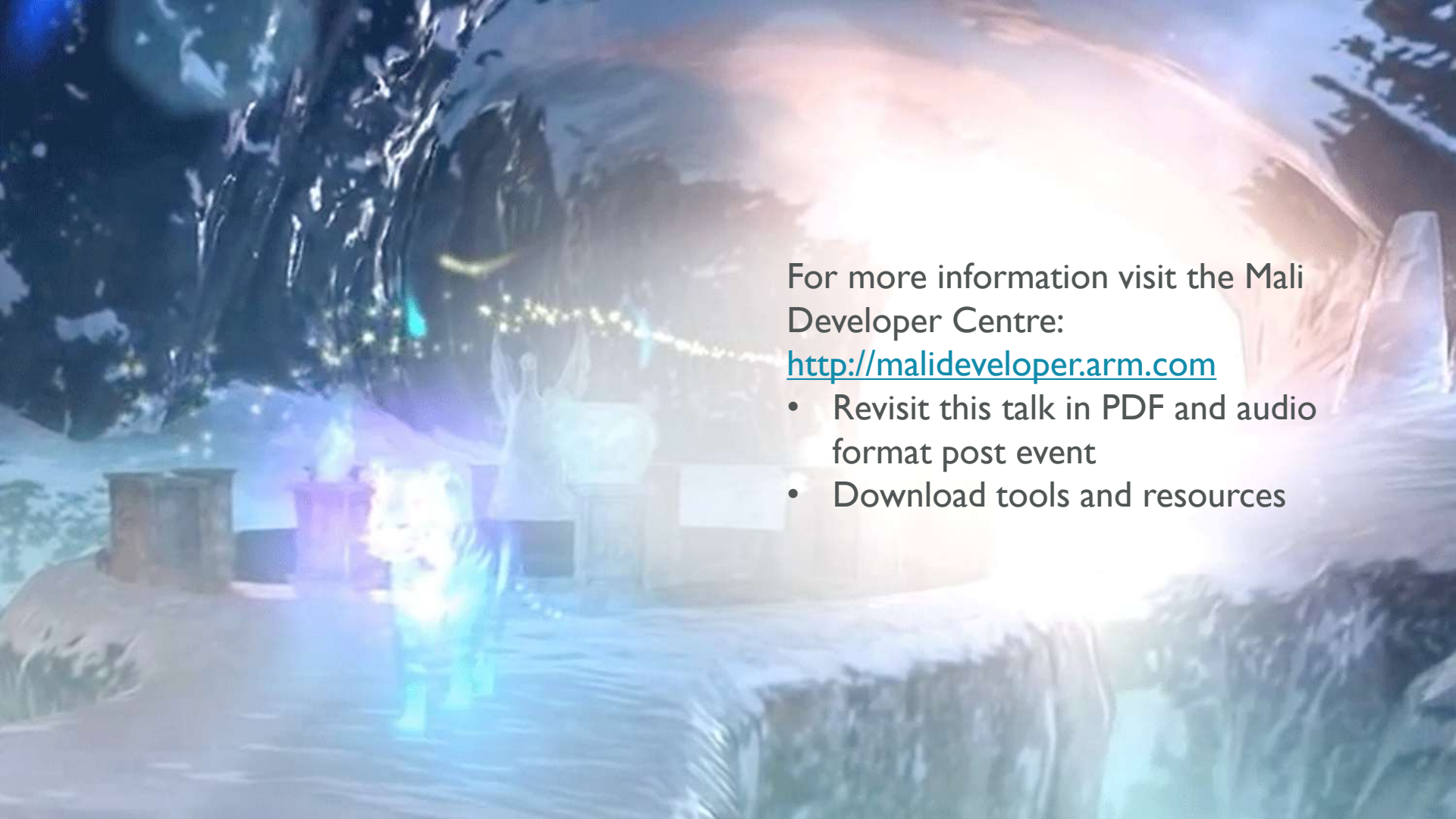
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Thanks! Questions?

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Up next:
- Patrick O'Luanaigh, nDreams
  - "Designing and Programming VR Games for Mobile Platforms"

Mali VR SDK
- http://malideveloper.arm.com/resources/sdks/mali-vr-sdk/

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For more information visit the Mali Developer Centre: http://malideveloper.arm.com

- Revisit this talk in PDF and audio format post event
- Download tools and resources

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