INTO THE NEW
**BREW 2007 CONFERENCE**

# 3D Graphics and SpeqG Update

**David Ligon**

**Product Manager, Staff**

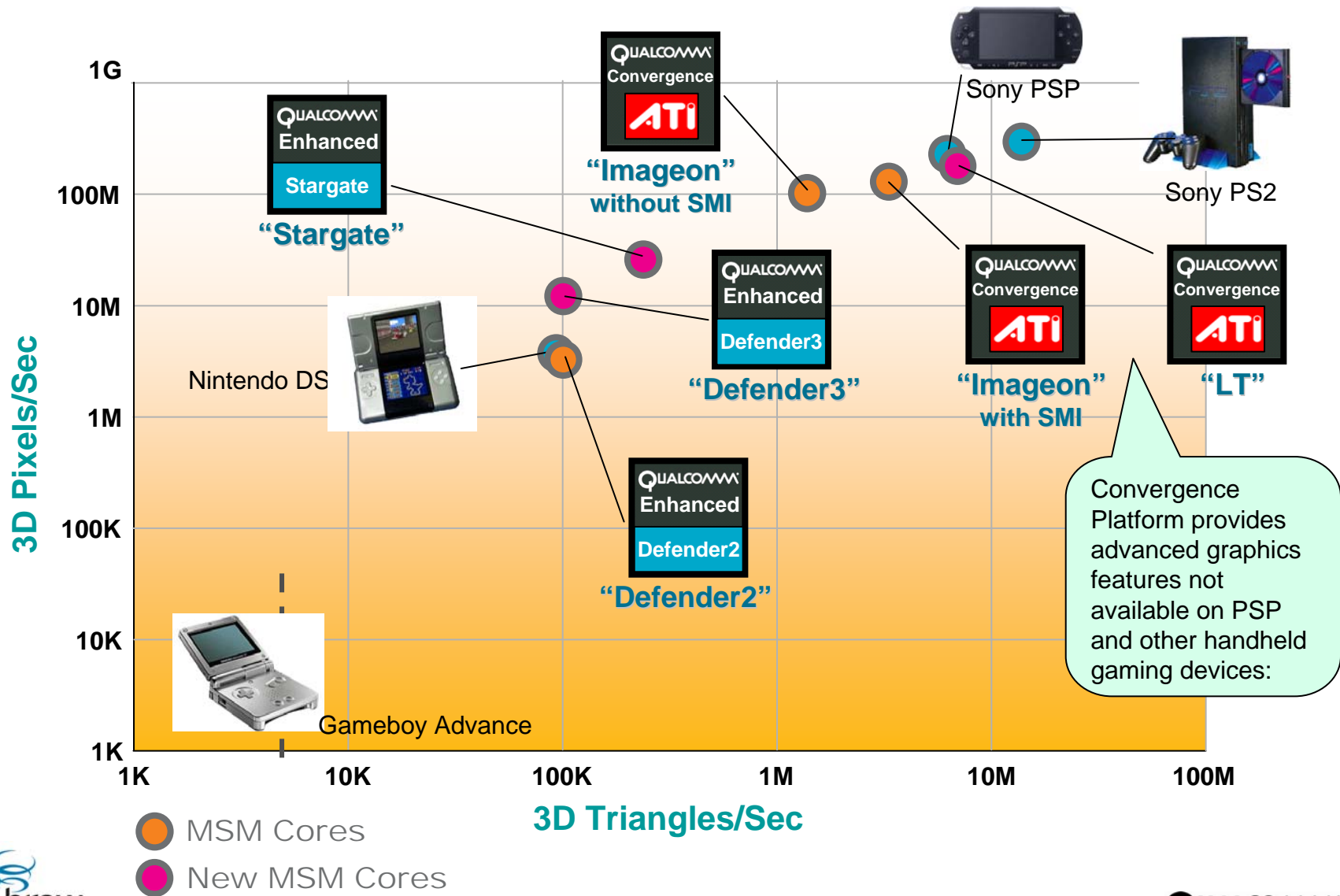**QUALCOMM Incorporated**

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# Agenda

- **Overview of QUALCOMM® Graphics Cores**
- **MSM6xxx Update, Including New Cores**
- **MSM7x00 Update**
- **MSM7850 Introduction**
- **SpeqG 100M Gaming Phone Alliance**

# QUALCOMM Graphics Core Performance



**3D Pixels/Sec** (y-axis): 1K, 10K, 100K, 1M, 100K, 1M, 10M, 100M, 1G

**3D Triangles/Sec** (x-axis): 1K, 10K, 100K, 1M, 10M, 100M

"Stargate"

"Imageon" without SMI

Sony PSP

Sony PS2

"Defender3"

"Imageon" with SMI

"LT"

Nintendo DS

"Defender2"

Gameboy Advance

Convergence Platform provides advanced graphics features not available on PSP and other handheld gaming devices:

MSM Cores

New MSM Cores

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# Graphics Core MSM Lineup

| Gfx Core | Peak Performance | In Production | 2007 | |
|---|---|---|---|---|
| LT 3D<br>LT 2D | 21M TRIS /SEC<br>133M PIXELS /SEC<br>532M PIXEL REJECT /S<br>798M TOTAL INST /S | | | **7850** DOrB<br>Q1 |
| Imageon 3D<br>Imageon 2D | 4M TRIS /SEC<br>133M PIXELS /SEC | **7500** DOrA  **7200** HSUPA | **7200A** HSUPA  **7600** DOrA HSUPA  Q1 | **7500A** DOrA  Q4 |
| Stargate 3D<br>ARM 2D | 600K TRIS /SEC<br>90M PIXELS /SEC | | **6280A** HSDPA  Q3 | |
| Defender3 3D<br>ARM 2D | 225K TRIS /SEC<br>22M PIXELS /SEC | **6175** 1x  **6800A** DOrA  **6575** DOr0 | | |
| Defender2 3D<br>ARM 2D | 225K TRIS /SEC<br>7M PIXELS /SEC | **6550** DOr0  **6550A** DOr0  **6800** DOrA  **6280** HSDPA<br>**6150** 1x  **6275** HSDPA | | |
| ARM-DSP 3D<br>ARM 2D | 50K - 100K TRIS /SEC<br>400K - 1M PIXELS /SEC | **6500** DOr0  **6100** 1x  **6250A** WCDMA  **6260** HSDPA<br>**6125** 1x  **6250** WCDMA  **6255A** WEDGE  **6245** WEDGE | | |
| No 3D<br>ARM 2D | N/A | **6050** 1x  **6025** 1x  **QSC 6030** 1x<br>**6000** 1x  **QSC 6020** 1x  **QSC 6010** 1x  **6225** HSDPA | **QSC 6055** 1x  Q1  **QSC 6075** DOrA  **QSC 6065** 1x  Q2  **7525** DOrA  **7225** HSUPA  **6260-1** HSDPA  **QSC 6270** HSDPA  **QSC 6245-1** HSDPA  **QSC 6240** HSDPA  Q3 | **QSC 6085** DOrA  **QSC 1100** 1x  Q4 |

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# Core Feature Summary

| Gfx Core | APIs Accelerated | MAX LCD |
|---|---|---|
| LT 3D<br>LT 2D | OpenGL ES 2.0<br>Direct 3D Mobile, SM3<br>JSR 297<br>BREW Render 2D<br>Direct Draw, GDI<br>OpenVG 1.1<br>SVG | WVGA<br>800x480 |
| Imageon 3D<br>Imageon 2D | OpenGL ES 1.0 Common<br>+ some OpenGL ES 1.1<br>Direct 3D Mobile, SM2<br>JSR 184<br>BREW Render2D<br>Direct Draw, GDI | WVGA<br>800x480 |
| Stargate 3D<br>ARM 2D | OpenGL ES 1.1 Common<br>JSR 184 | QVGA<br>320x240 |
| Defender3 3D<br>ARM 2D | OpenGL ES 1.0 Common Lite<br>JSR 184 | QVGA<br>320x240 |
| Defender2 3D<br>ARM 2D | OpenGL ES 1.0 Common Lite<br>JSR 184 | QVGA<br>320x240 |
| ARM-DSP 3D<br>ARM 2D | Software / Firmware only<br>OpenGL ES 1.0 Common Lite<br>[*no dedicated hardware*] | QCIF+<br>220x176 |
| | | |

**Increase in LCD pixel resolution requires higher graphics performance**

2003 — QCIF+
2004 — QVGA
2005 — PSP
2006
2007 — WQVGA / VGA
2008 — WVGA / WXGA

DUCATI 3D EXTREME
SUPERSCAPE
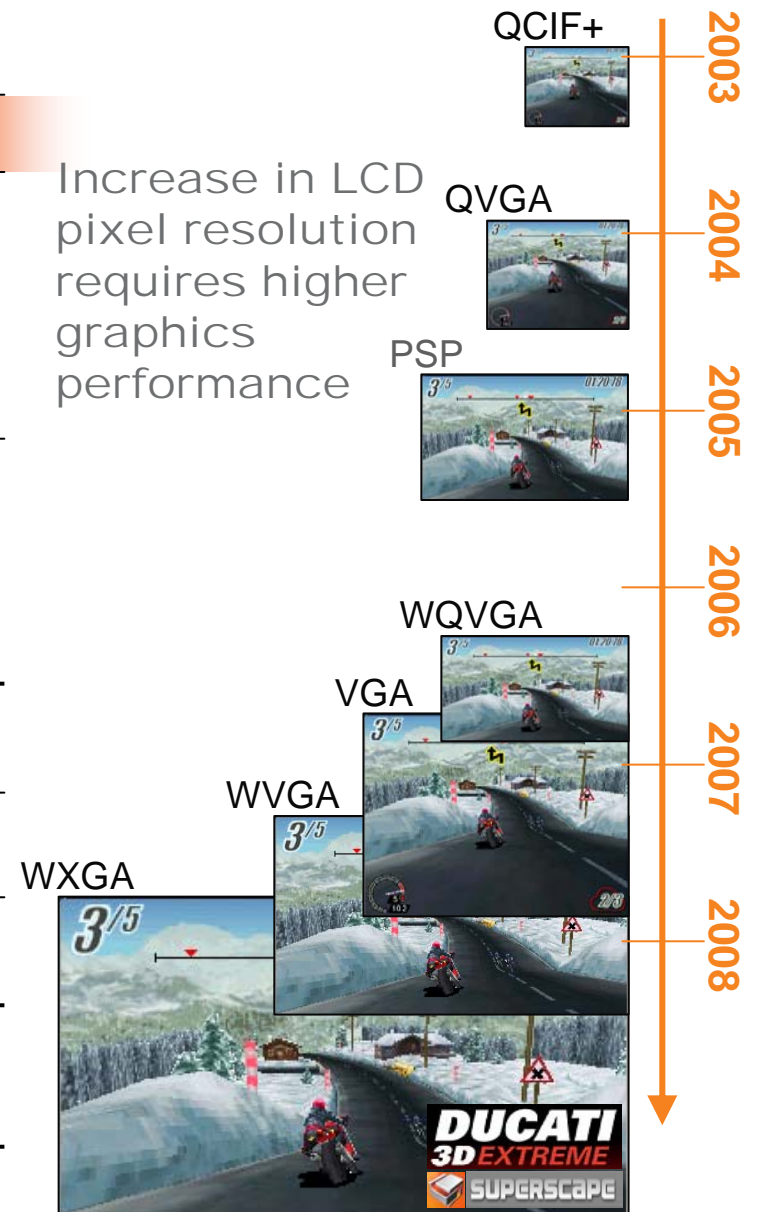
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# "Defender & Stargate" in the MSM6xxx Platgforms

## ARM Processor
- Single Processor ARM 9
- Fixed Point scaler CPU

## QDSP-4
- 3D Geometry and Lighting
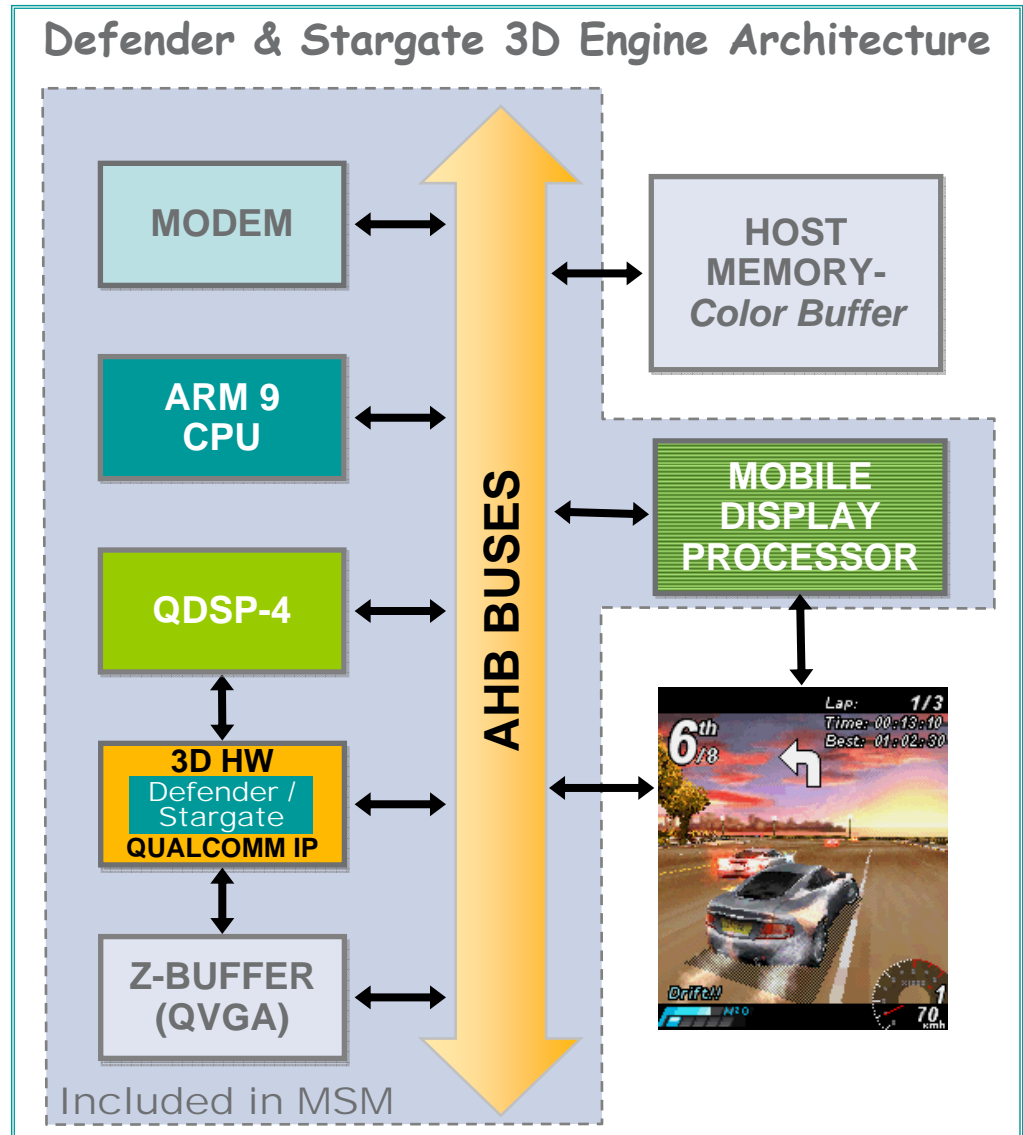- Audio

## QUALCOMM designed 3D hardware
- *3D Rastarization*
- Hardware Z buffer
- Early Z test
  - efficient processing and power
- 16K optimized texture cache

## Mobile Display Processor
- Concurrent 3D rendering & LCD update
- Window/Image scaling, rotation
- Transparent, over and under layers
- Color conversions

## Benefits
- Triangle and pixel system balance
- CPU freed up for game play
- Outstanding power/performance ratio
- Defender: OpenGL® ES 1.0 Lite
- Stargate: OpenGL ES 1.1 Common
- JSR 184
- uiOne™ 3D support

### Defender & Stargate 3D Engine Architecture



MODEM

ARM 9 CPU

QDSP-4

3D HW
Defender / Stargate
QUALCOMM IP

Z-BUFFER (QVGA)

AHB BUSES

HOST MEMORY- *Color Buffer*

MOBILE DISPLAY PROCESSOR

Included in MSM

# Hardware Provides a Better Gaming Experience with Reduced Power (Defender2 examples)
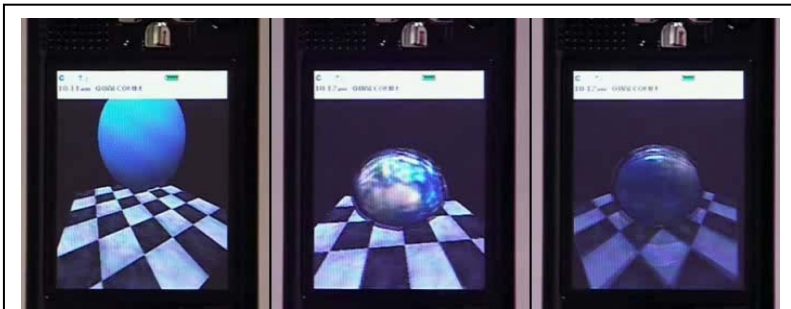


**CarBen 1**
**OpenGL ES Software**
QVGA (320x240)

- 15 locked at 15 fps
- 137 mA
- 157 mA with sound
- 18 fps Max

**CarBen 1**
**OpenGL ES Hardware**
QVGA (320x240)

- 15 locked at 15 fps
- 117 mA
- 130 mA with sound
- 65 fps Max



**Hardware**
**Ducati Extreme 3D**
**BREW OpenGL ES 3D**
QVGA (320x240)

- 20 frames per second
- 156 mA
- Industry standard API

- 40% Higher Frame Rate

**Software**
**Ducati Extreme 3D**
**BREW SWERVE 3D**
QVGA (320x240)

- 14 frames per second
- 169 mA
- Highly Optimized Proprietary 3D API

# Over 40 Q3Dimension Hardware Enabled Phones Across 5 Carriers (March 2005)

Kyocera W44K

Casio W43CA

Sanyo W42SA

Pantech IMU170

SCH B630

Motorola MS800

SGH Z630

LG VX9800

SCH B450

CA NX9200

Hitachi W41H

Moorola MS800

SCH B100

Casio W51CA

SCH B540

W51K

Kyocera W42K

Toshiba DRAPE W46T

SCH B590

W51S

W51H

Kyocera W43K

SE W42S

SE W42CA

Kyocera W51K

SCH B300

W51P

W51SA

W51CA

Sanyo W43SA

SE W44S

Kyocera W41K

Sanyo M1

Hitachi W42H

Samsung SPH610

Toshiba W47T

Hitachi W43H

Casio W41CA

SE W43S

SE W41S

LG VX9900

LG VX9400

**OpenGL ES on BREW**

Other APIs

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# Defender2, Defender3, and Stargate Comparison

| Feature | Defender2 | Defender3 | Stargate |
|---|---|---|---|
| API | OpenGL ES 1.0 Common Lite | OpenGL ES 1.0 Common Lite | OpenGL ES 1.1 Common |
| Early Z test | Yes | Yes | Yes |
| Texture compression | No | Yes | Yes |
| Fast texture bypass mode | No | Yes | Yes |
| Fast blending pipeline | No | Yes | Yes |
| Hardware backface culling | No | No | Yes |
| Fast geometry to pixel engine interface | No | No | Yes |
| Point primitive hardware | No | No | Yes |
| Viewport projection hardware | No | No | Yes |
| Trilinear filter hardware | No | No | Yes |
| Single pass multitexture combiner | No | No | Yes |
| Color cache pre-fetch | No | No | Yes |

# "Imageon+" in the MSM7200(A), MSM7500(A), and MSM7600

**ARM 9 and ARM 11 Dual CPU**
- Fixed Point Scaler ARM 9 and ARM 11
- ARM 11 for Game Play

**QDSP-5**
- Audio

**Integrated ATI 2D/3D Hardware**
- *2D BLT and Line support*
- *3D Geometry & Rasterization*
- Texture compression (ATITC)
- Hardware color, Z, and stencil buffers

**Mobile Display Processor (MDP)**
- Concurrent 3D rendering & LCD update
- High quality scaling of 3D frames
- Orthogonal image rotation
- Transparent, over and under layers
- High quality color conversion
- Memory, EBI2, MDDI, and TV out

**Benefits**
- 2D Hardware for high resolution displays
- Complete 3D Hardware pipeline
- Full audio concurrency (MP3, AAC+, 3DFX)
- Integrated high speed memory system
- 3D: OpenGL ES 1.0+ Common
- JSR 184, Direct 3D - Shader Model 2
- 2D: Render2D on BREW, GDI, Direct Draw
- uiOne 3D support

## Imageon + MSM 3D Engine Architecture



Diagram blocks: ARM 9 CPU, MODEM, ARM 11 MM CPU, QDSP-5 (Audio), Improved ATI IMAGEON 2D/3D HW, COLOR Z, and STENCIL BUFFERS — all connected to AXI BUS (2x64 Bits) — SYSTEM MEMORY 2, SYSTEM MEMORY 1 (Built-in), MOBILE DISPLAY PROCESSOR. Included in MSM.
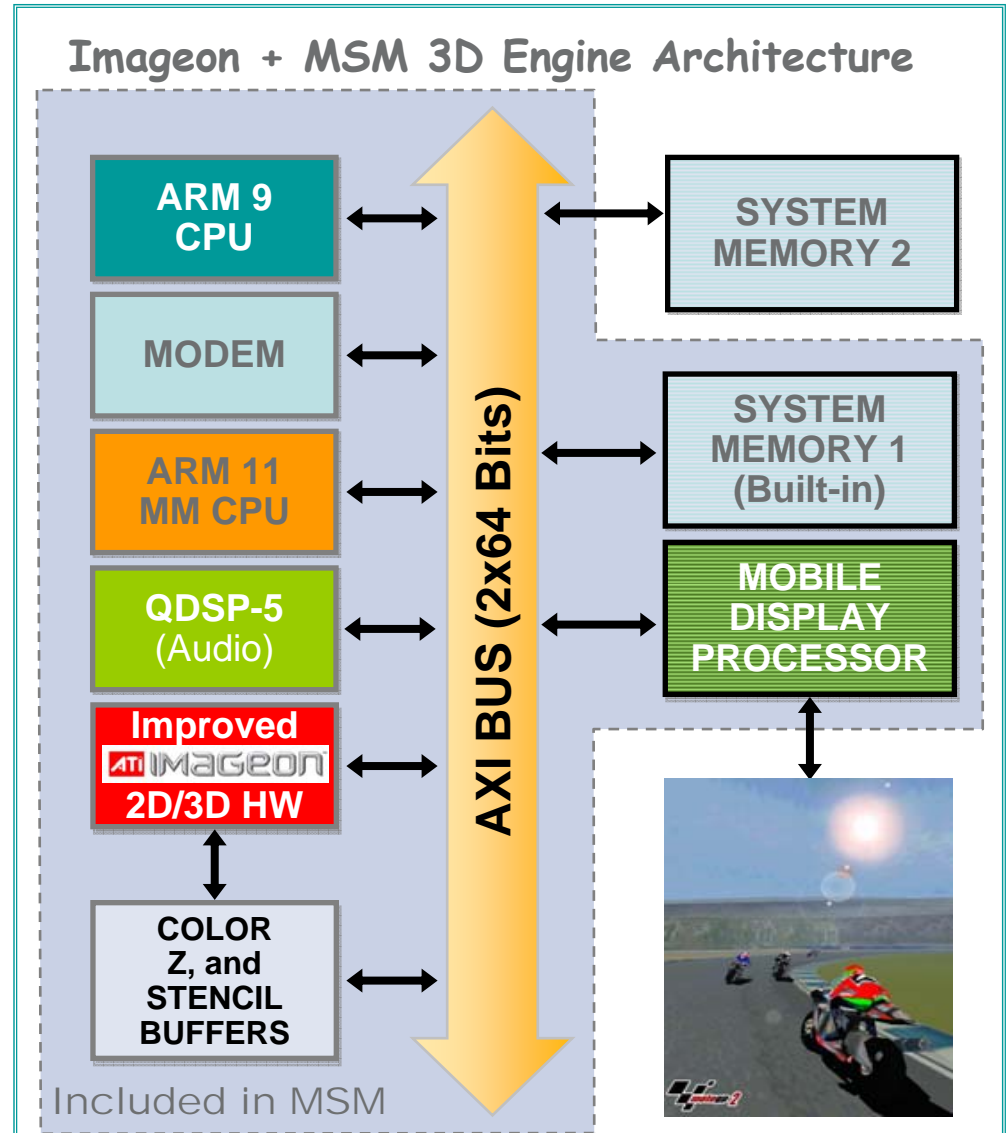
# MSM7500, MSM7200, and MSM7600 Feature Benefits

- Highly efficient "fixed function" pipeline
- Multitexture per-pixel lighting
- Up to 12x more efficient than PSP

Shadows

x = 

Glare

+ = 

Texture 1 Material    Texture 2 (Light Map)    Lighted Surface
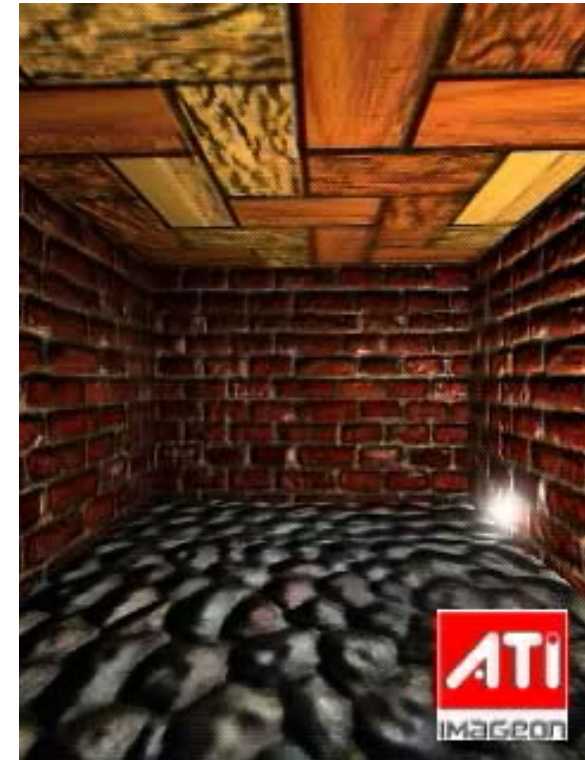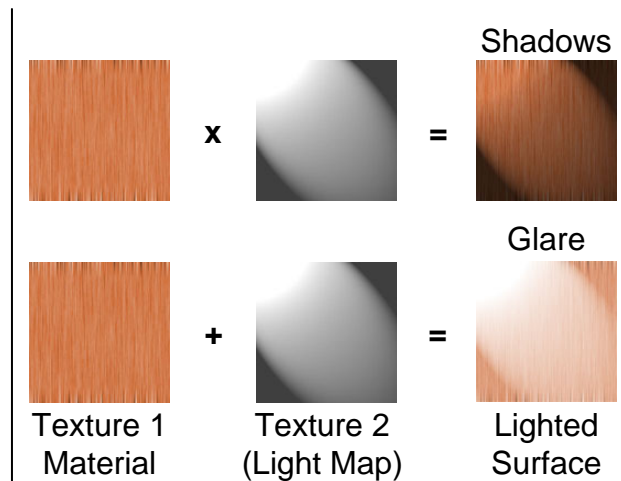
| | Simple Light Map | | Bump Map Lighting |
|---|---|---|---|
| Imageon with multitexture | Requires 1 rectangle<br>Requires 1x pixels | | Requires 10 triangles<br>Requires 1x pixels |
| PSP single texture | Requires 2 rectangles<br>Requires 2x pixels | | 120+ triangles<br>12x pixels |

# MSM7xxx MDP Scaling Increases Performance by 4x

- Very high quality 4 Tap polyphase non-integer scaling
- No impact on 3D graphics pipeline performance
- **4X peak pixel performance gain by rendering at smaller resolution**
- Particularly useful for high resolution, small dimension displays
- OpenGL ES Extension allows use of scaled or full viewports
- Easily port between different size LCDs with similar aspect ratio

GPU

System Memory

MDP 4 Tap Polyphase Scale

LCD

NOTE: QUALCOMM performance specifications are native resolution. Effective pixel performance is up to 4X specifications
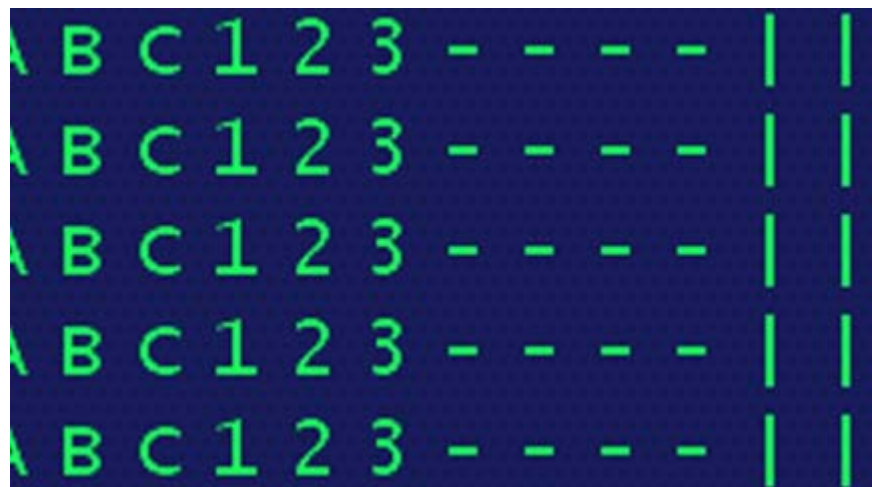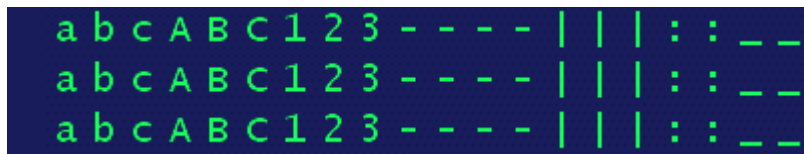
Actual output of scale algorithm

# The MSM7200(A), MSM7500(A), /MSM7600 OpenGL ES 3D Benchmark

| LCD Size | Rendering Quality | 5139 CRM |
|---|---|---|
| Native 480x640 (VGA) | Excellent | 33.9 fps |
| Native 800x480 (WVGA) | Excellent | 25.2 fps |
| Scaled 400x240 (WQVGA) to 800x480 (WVGA) | Very Good | 52.5 fps |

## Specs:

3D Geometry
- Avg Triangles Rendered / Frame: 5047*
- Models: 3571* Triangles

Lighting
- Static: 20 Ray traced lights*
- Dynamic: Parallel 1x, Point 2x bump-map per-pixel lights

Textures
- Total Textures: 63* (2.33 MB with compression)

Audio
- MP3 2x (1.73 MB)

Particle Systems
- Fire/Smoke, Explosions, Missile Trails, Lens Flares, Motion Blur

VGA 7500 FPS: 32 FPS VGA*

# MSM7200(a), MSM7500(A), MSM7600 Graphics Core Performance Summary

| | Native Peak Performance | Effective Peak Perf. Using MDP Scale |
|---|---|---|
| **Triangle rate** | 4M tri /s | 4M tri /s |
| **Pixel draw rate** | 133M pixels /s | 532M pixels /s |
| **Multitexture draw rate** | 67M pixels /s | 266M pixels /s |
| **Z/stencil reject rate** | 133M pixels /s | 532M pixels /s |
| **Texture filtering rate** | 133M bilinear filtered texels /s | 532M bilinear filtered texels /s |
| **Alpha blending rate** | 133M pixels /s | 532M pixels /s |

# "LT" in the MSM7850

**ARM 9 and Scorpion Lite Dual CPU**
- Fixed Point Scaler ARM 9
- Scaler & Vector Floating Point Scorpion

**QDSP-5**
- Audio

**Integrated ATI 3D Hardware**
- *Programmable graphics pipeline*
- Unified vertex and pixel processor
- Early Z test
- Same high quality texture compression and dedicated memory as MSM7x00

**Mobile Display Processor (MDP)**
- Concurrent 3D rendering & LCD update
- Same high quality image/frame processing as MSM7x00
- Memory, EBI2, MDDI, and TV out

**Benefits**
- Programmable graphics effects
- Improved performance and efficiency
- Full audio concurrency (MP3, AAC+, 3DFX)
- Integrated high speed memory system
- Multimedia Interoperability
- 3D: OpenGL ES 2.0
- 3D: JSR 184, Direct 3D Shader Model 3
- 2D: OpenVG, SVG, GDI, Direct Draw
- uiOne support

## Imageon + MSM 3D Engine Architecture



ARM 9 CPU

MODEM

Scorpion Lite MM CPU

QDSP-5 (Audio)

ATI LT

COLOR Z, and STENCIL BUFFERS

AXI BUS (2x64 Bits)

SYSTEM MEMORY 2

SYSTEM MEMORY 1 (Built-in)

MOBILE DISPLAY PROCESSOR

Included in MSM

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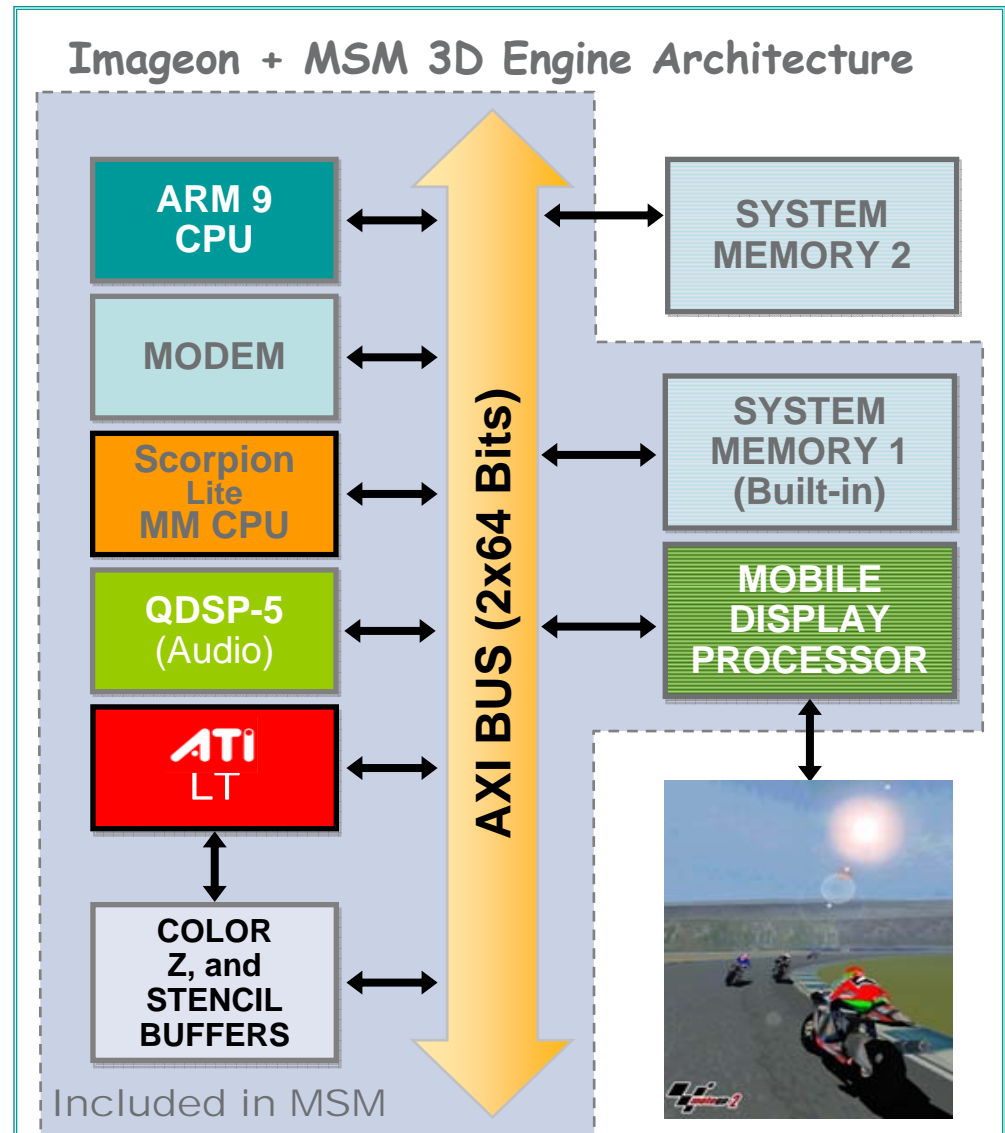
# MSM7850 LT Shader Graphics

- **XBOX 360 graphics scaled for mobile devices**
- **Highly compatible API and functionality**
- **Scaled by ATI**

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# Pipeline Differences

- **MSM7200(A), MSM7500(A), MSM7600 Fixed Function Pipeline**
  - Highest performance and power for a given chip area



- **MSM7850 Programmable Pipeline**
  - Highest flexibility for advanced gaming effects



**LT Unified GPU**
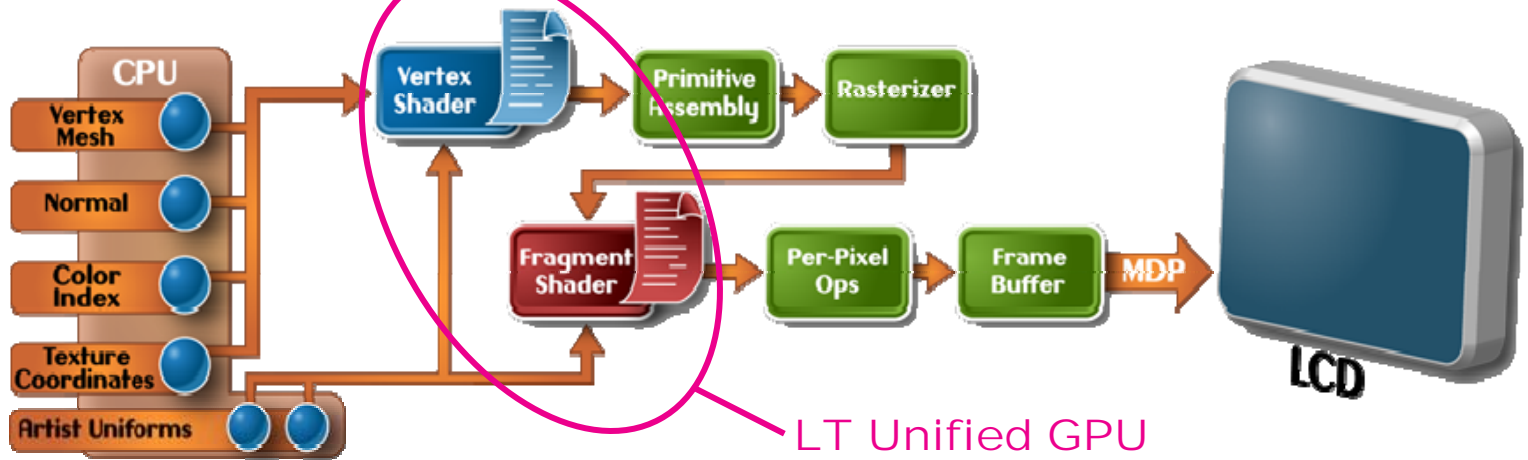
# MSM7850 LT and Scorpion Performance Benefits

- **Compatibility mode for MSM7x00 Platforms**

- **Up to 3X Imageon Performance**

- **Developer programmable for specialized effects**

- **Highly efficient Unified Shader**
  - Triangle and pixel performance automatically balanced on LT

- **Up to 512 textures on the LT vs 2 on the Imageon in a single pass**
  - Games typically use less than 4

- **Early depth reject 4 pixels/clock vs 1 pixel/clock on Imageon**
  - Early depth test reduces pixel processing requirements
  - 532M pixels/sec peak reject for LT vs 133M pixels/sec for Imageon

- **2 and 4 Sample Multi-Sample Anti-Aliasing at full rendering speed**

- **Scorpion vector floating point processor big advantage for game developers**
  - Venum vector processor for physics, skinning, tessellation, etc.



**Auto-balancing Unified Shader**

**Independent Vertex & Pixel Shader**
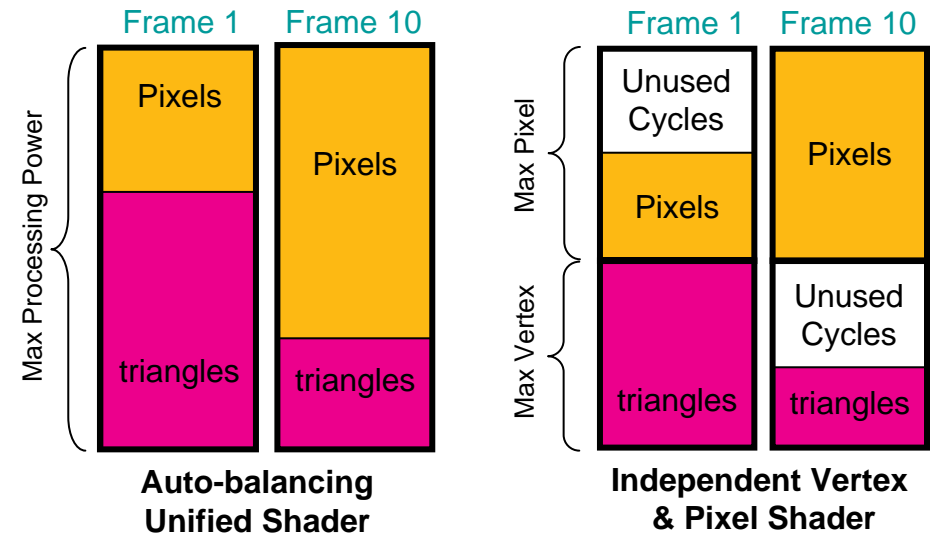
# "Scorpion" Mobile Microprocessor Core

- **Scorpion – low power, high performance superscalar CPU developed by QCT**
  - First to develop 1GHz CPU for battery powered wireless applications
  - Low power, low leakage, 65-nm process
  - Specifically designed and optimized for MSM solutions
  - ARM v7 compliant; QCT is an ARM architecture licensee

Scorpion CPU

- **VeNum 128 bit SIMD – low power, high performance multimedia coprocessor**
  - Up to 2X performance boost for multimedia applications
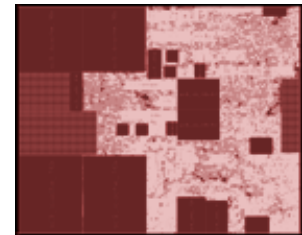
| Feature | Intel XScale PXA270 | Cortex-A8* (Tiger) | Scorpion* |
|---|---|---|---|
| Frequency | 624MHz | < 600MHz TI OMAP 3 is 550MHz | up to 1GHz |
| Instruction set | V5 WMMX | V7 64 bit Neon | V7 128 bit VeNum |
| Performance | 780 DMIPS | 1200 DMIPS | 2100 DMIPS |
| Power @ 600 MHz | 480 mWatts | 300 mWatts | 240 mWatts |

**CPU Delivers Up To 16x Performance Over Previous QCT Generations**

**Collaboration Between QCT and ARM on v7 Architecture**
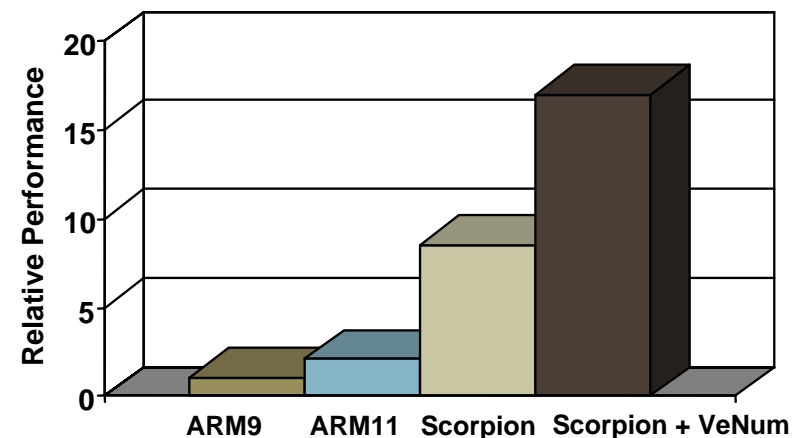


NOTE: Scorpion is based on ARM v7 architecture. VeNum is based on ARM SIMD Neon architecture

# MSM7850 LT Graphics Core Performance Summary

|  | Native Peak Performance | Effective Peak Perf. *Using 4X MDP Scale* |
|---|---|---|
| Triangle rate | Up to 21M tris /s | Up to 21M tris /s |
| Pixel draw rate | 133M pixels /s | 532M pixels /s |
| Z/stencil reject rate | 532M pixels /s | 2128M pixels /s |
| Vector Instruction rate | 133M instructions /s | 532M instructions /s |
| Total Instruction rate | 798M instructions /s | 3192M instructions /s |
| Texture filtering rate | 133M bilinear filtered texels /s | 532M bilinear filtered texels /s |
| Alpha blending rate | 133M pixels /s | 532M pixels /s |

# Introducing

# SpeqG™

## 100 million
## gaming phone alliance

# SpeqG - 100M Gaming Phone Alliance (GPA) Proposition

- *Alliance between Content Providers, Carriers, OEMs, and QUALCOMM to jump start a healthier gaming ecosystem*

3D HW enabled Handsets

Better Games

Building a healthy gaming ecosystem increases revenue for all

Higher ARPU

Better Consumer Value
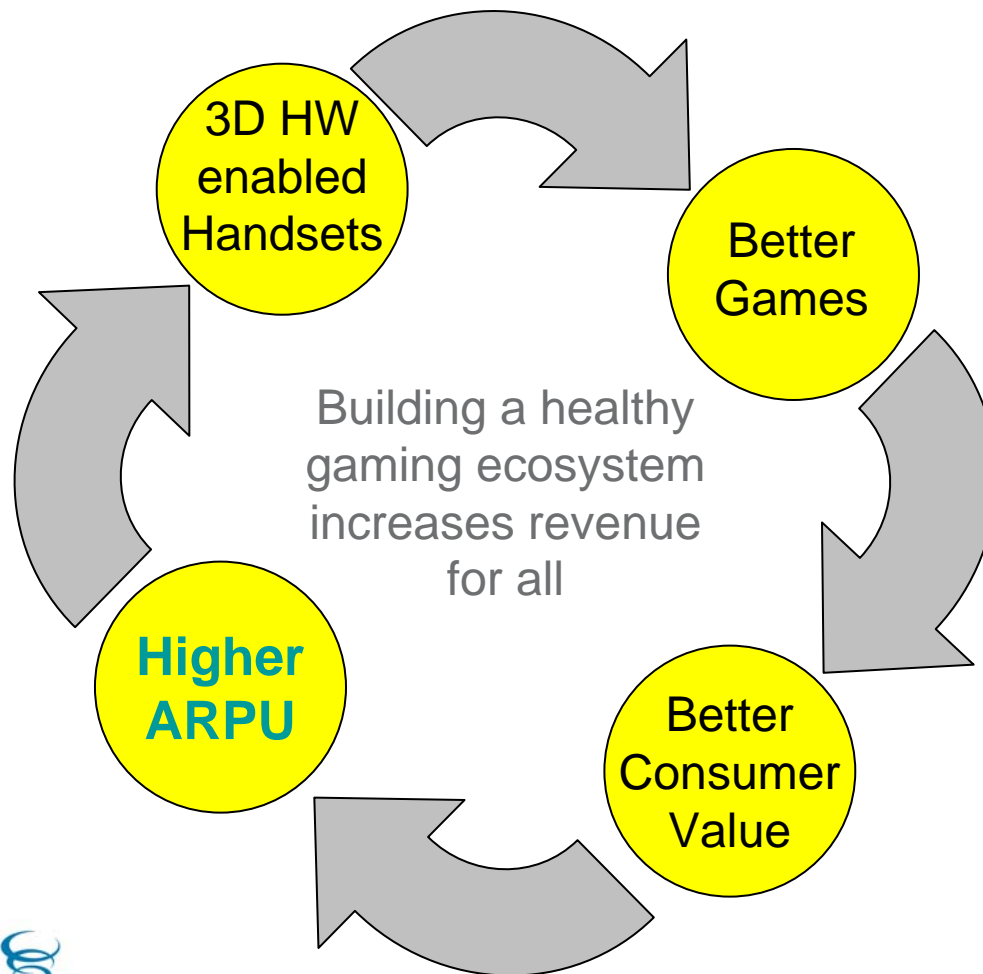
High volumes of 3D hardware enabled handsets with consistent APIs enable better games with better consumer value and higher ARPU

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# 3D Gaming Value Proposition

- **100M GPA Compliant Handsets combined with high speed 3G networks enable higher quality premium 3D mobile games at higher retail price points**

**3D hardware accelerated games offer a higher quality consumer experience**

**3D games fetch 40% to 90% higher price points on Verizon 3G network**

Bomberman 3D
$4.5/mo  Japan

Brothers In Arms 3D
$9.49 un $3.49/mo
US

Need For Speed 3D
$13.49 un $5.49/mo
US

HUDSON

gameloft

EA

Bomberman 2D
$2.7/mo  Japan

Brothers In Arms 2D
$6.99 un $2.99/mo
US

The Sims II 2D
$7.99 un $3.99/mo
US

VICTORY!

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# ARPU Generating Services: Games and More...
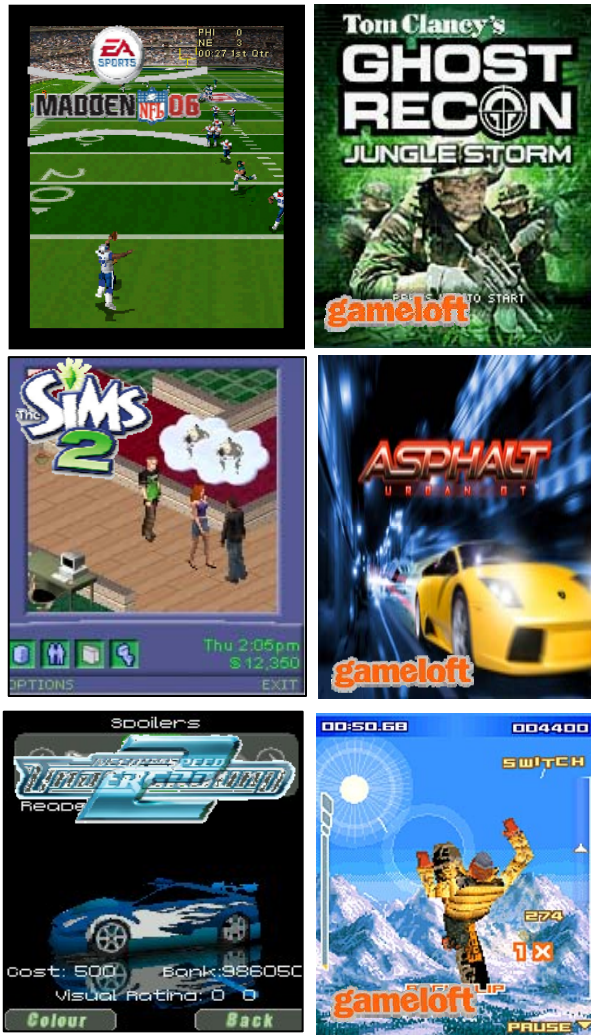
| Games | Avatar Applications | 3D UIs | GPS/Mapping |
|---|---|---|---|

# QUALCOMM SpeqG Role

- **QUALCOMM:**
  - Develop SpeqG specification with Carrier, OEM and Content Provider
  - Host and maintain SpeqG web site
    - Public Site: SpeqG member list SpeqG content videos, SpeqG Handset list
    - Private site: Distribution of Specification, benchmarks, tools, training materials, sample applications
  - Produce developer tools, training materials, community tools, discovery tools such as the BREW Signature Solution
  - Work with CP to provide benchmarks and verification tools
  - Produce marketing materials
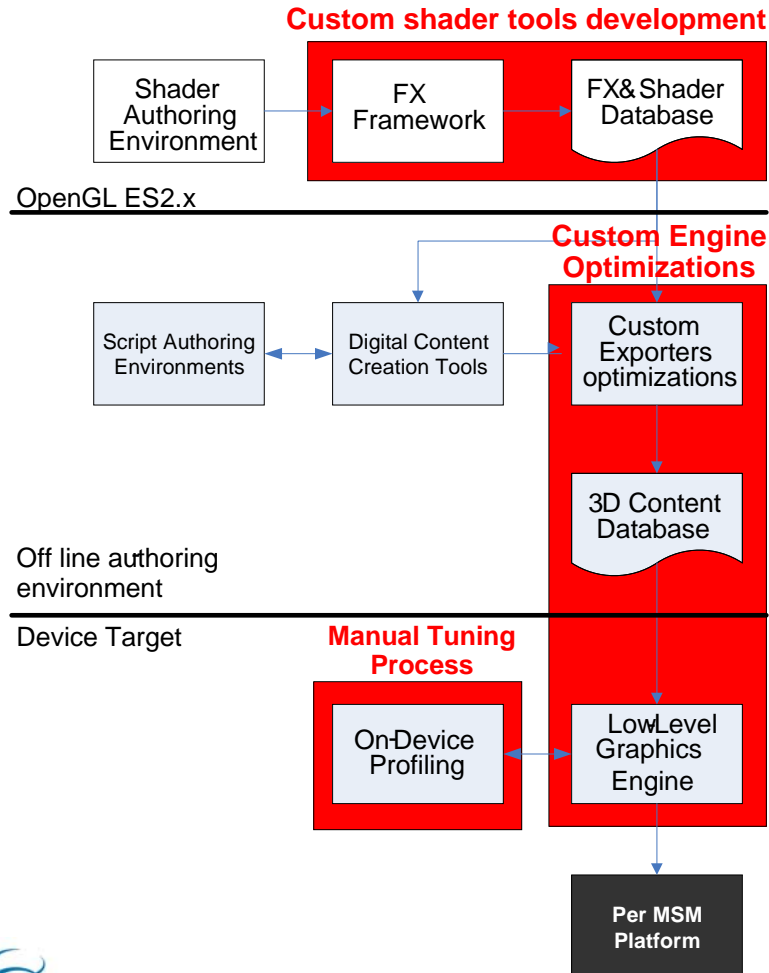
- **SpeqG Specification**
  - Minimum requirements for high volumes of phones
  - Focus on most important common requirements for phones
  - Plenty of room and suggestions for differentiation
  - Two-tiered specification to successfully support 3D gaming:
    - 100M GPA Mainstream Handsets
    - 100M GPA High-End Handsets
  - Verification tools for SpeqG devices
  - Includes 3D graphics performance and APIs (BREW, JAVA and WinMobile)

Memory
APIs
Vibration support
Connectivity
Performance
File size
Audio
Event handling
LCD Size
Button usage
Download Size
Veification

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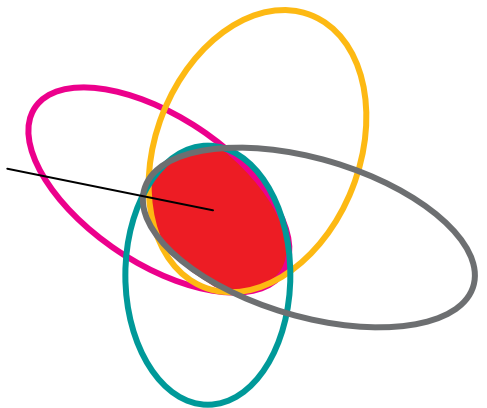
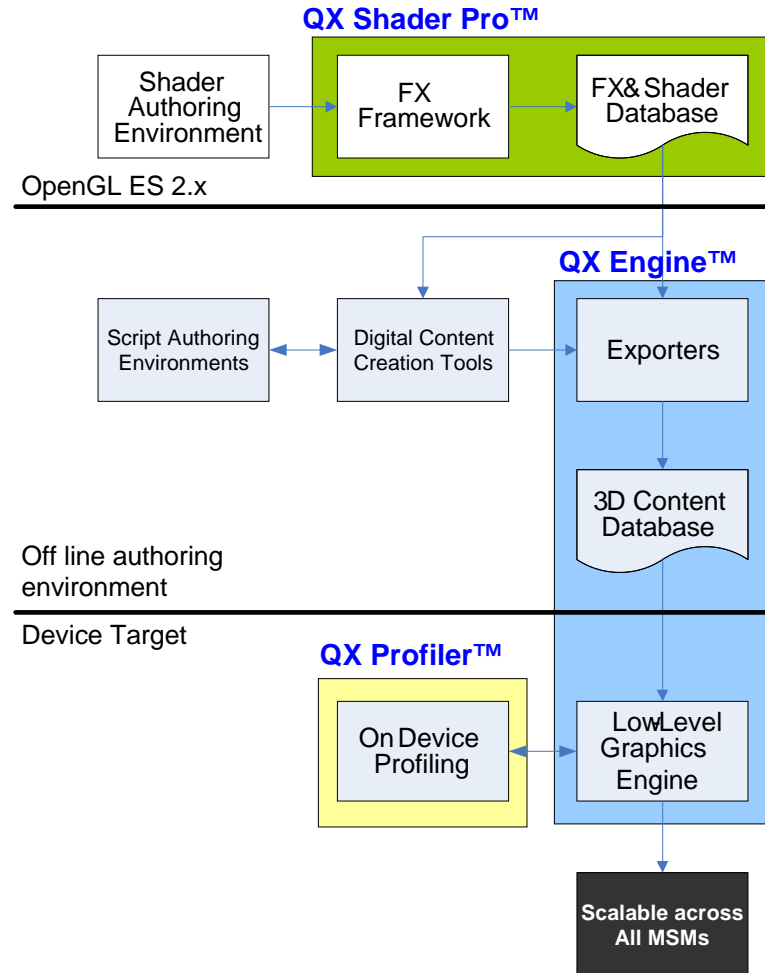# QX Products for MSM Development and Optimization

**The problem for game developers:**
Custom development for each MSM™ 3D platform
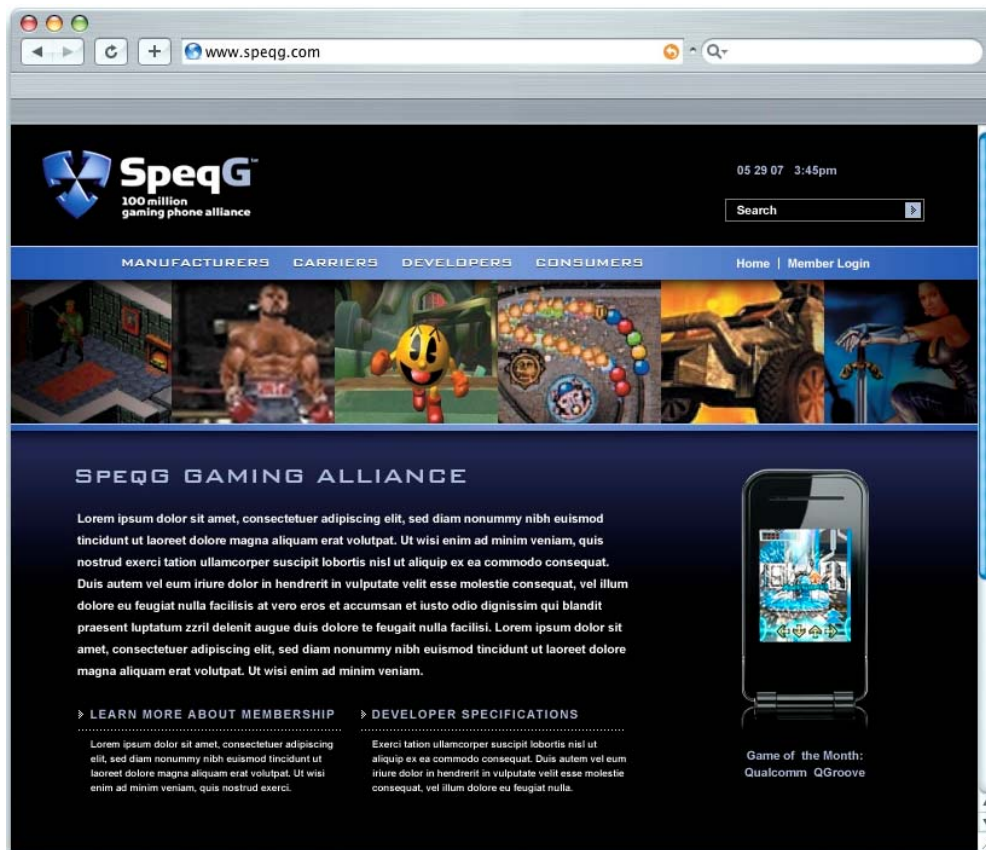Every component is a time consuming process

**The solution:**
Provide the components every developer needs

**Custom shader tools development**

Shader Authoring Environment → FX Framework → FX&Shader Database

OpenGL ES2.x

**Custom Engine Optimizations**

Script Authoring Environments ↔ Digital Content Creation Tools → Custom Exporters optimizations

3D Content Database

Off line authoring environment

Device Target

**Manual Tuning Process**

On-Device Profiling ↔ LowLevel Graphics Engine

Per MSM Platform

**QX Shader Pro™**

Shader Authoring Environment → FX Framework → FX&Shader Database

OpenGL ES 2.x

**QX Engine™**

Script Authoring Environments ↔ Digital Content Creation Tools → Exporters

3D Content Database

Off line authoring environment

Device Target

**QX Profiler™**

On Device Profiling ↔ LowLevel Graphics Engine

Scalable across All MSMs

**Provided on the SpeqG Secure Web Site**

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# www.SpeqG.com

**Significant /Carrier/Developer/OEM tools and documents available through the secure SpeqG Member web site**

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# "How do I Join the 100M Gaming Phone Alliance and *grab a share of the potential $3.5B SpeqG gaming market?*"

Sign simple Agreement to participate in the 100M GPA, by Category

**Content Provider**

- More revenue
- Higher return on investment per title to recover higher development cost for 3D

- Make available SpeqG tuned commercial titles for revenue generation
- Provide tuned demo content for promotion, testing and preload on handsets
- Share SpeqG enabled content portfolio and roadmap
- Participate in joint marketing

**Mobile Operator**

- Higher ARPU from gaming sector
- Reduction in subscriber churn

- Mandate graphics API, graphics performance and SpeqG features in relevant phone models
- Enhance game discovery through preloads, deck visibility and multiplayer gaming community services
- Participate in joint marketing

**OEM**

- Higher handset differentiation with carriers
- Increased handset value with distribution channels

- Incorporate SpeqG features in phones (better form factor, multi-button press, etc)
- Provide early access SpeqG devices to Content Providers
- Preload demo content to increase consumer awareness
- Participate in joint marketing

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# Conclusions

- QUALCOMM provides a wide range of best-in-class integrated graphics hardware for mobile 3D services
- All hardware features are available through industry standard APIs in the BREW environment
- QUALCOMM has new 3D graphics cores for select MSM6xxx Platforms - 100% backwards compatible with existing cores
- The MSM7850 incorporates the Scorpion low power floating point processor and an OpenGL ES 2.0 GPU
- The MSM 3D feature set improves performance even higher than published specifications while reducing power usage
- The SpeqG 100M Gaming Phone Alliance between Mobile Operators, Content Developers, and OEMs will accelerate a multi-billion dollar gaming market

# Conclusions

- 3G + 3D has shown to provide higher ASP and higher ARPU for gaming and graphics related services

- QUALCOMM provides wide range of best-in-class integrated graphics solutions with the MSM7200 comparable to the DS or PSP

- Single Chip Integrated graphics solution outperforms coprocessor, with lower cost, and higher volumes

- Graphics performance easily accessible through standard APIs such as OpenGL ES, Direct 3D Mobile and JSR 184

- Top tier content providers are supporting QUALCOMM's MSM Platforms
  - And QUALCOMM is supporting top tire content providers

- 100M Gaming Handset Alliance between Microsoft, QUALCOMM, Content Providers, Service Providers, OEMs, will accelerate a multi-billion dollar gaming market

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# MSM7850 LT Supports Current and Proposed Future API Standards in Hardware

- **3D APIs**
  - Supports OpenGL ES 2.0 specification which will be completed in 2007
    - > As does PS3
    - > Supports proposed OpenGL ES 2.1 specification expected ratification in 2008
  - Supports DX9 + some DX10 functionality
    - > As does XBOX 360
    - > Microsoft Shader Model 3
    - > Current Windows Mobile D3D API is DX7, Shader Model 2
  - Supports Java JSR 297
    - > Programmable API replacement for JSR 184

- **2D**
  - OpenVG 2D API
    - > Hardware accelerated base API for SVG and Flash
  - Windows Mobile Direct Draw, GDI, and GPE

- **Backwards compatible with MSM7500**
  - Compatibility mode for MSM7500 OpenGL ES on BREW
  - Available DX7 driver compatible with MSM7500
  - JSR 297 is a superset of JSR 184
  - QUALCOMM provided tools for cross-MSM-platform optimization

# Thank You

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