Mobile GPUs

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Agenda

• SoCs
• Case Studies
  – NVIDIA Tegra 2, Tegra 3
  – Imagination Technologies’ PowerVR SGX Series5XT
  – Apple iPad (2012)
• Future
• Note about sources

What is an SoC?

• System-on-a-Chip
  – CPU, GPU, DSP, I/O
  – Single-chip solution
• Top mobile SoC vendors:
  – Qualcomm, Apple, TI, Samsung, NVIDIA
• Advantages of using SoCs?
• Disadvantages?
• We will see all consumer chips converge to SoCs

Mobile SoC Market Share 2011

Market Share Data from PC Perspectives
### The Constraints of Mobile

- **Energy**
  - Cell phone battery capacity of 5-7 Wh (tablets 20-40 Wh)
  - How much energy can our chips consume?
- **Area**
  - PCB size constraints
  - Cooling constraints

### Brief Discussion of ARM

- RISC CPU vendor that currently dominates mobile
- Mobile Designs: Cortex-A8, A9, A15
- Fabless Designer
  - Core Design Licensees
  - Architecture Licensees
    - Qualcomm Scorpion/Krait
    - NVIDIA

### Some Energy Numbers

<table>
<thead>
<tr>
<th>Power Consumption Comparison</th>
<th>Apple iPhone 4 (AT&amp;T)</th>
<th>Apple iPhone 4S (AT&amp;T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idle</td>
<td>0.7W</td>
<td>0.7W</td>
</tr>
<tr>
<td>Launch Safari</td>
<td>0.9W</td>
<td>0.8W</td>
</tr>
<tr>
<td>Load AnandTech.com</td>
<td>1.0W</td>
<td>1.1W</td>
</tr>
<tr>
<td>Maps (Determine Current Location via GPS/Wifi)</td>
<td>1.3W</td>
<td>1.4W</td>
</tr>
</tbody>
</table>

Data from AnandTech
Some Contributors to Switching Energy

- Off-chip Interconnect (to DRAM)
  - Bandwidth is expensive
  - Minimize reasons to fire up memory bus
- High frequencies
  - Requires increased voltages

Some Theoretical Performance Numbers

<table>
<thead>
<tr>
<th></th>
<th>Apple iPad 2</th>
<th>ASUS Transformer Prime</th>
<th>Some Nice Desktop</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>A5 @ 1GHz</td>
<td>Tegra 3 @ 1.4GHz</td>
<td>Sandy Bridge @ 3.4GHz</td>
</tr>
<tr>
<td>GPU</td>
<td>POWERVR SGX543MP2 @ 250MHz</td>
<td>Mobile GeForce @ 500MHz</td>
<td>GTX680 @ 1GHz</td>
</tr>
<tr>
<td>Memory Interface</td>
<td>64-bit @ (maybe) 800MHz = 6.4GB/s</td>
<td>32-bit</td>
<td>256-bit @ 6GHz = 192GB/s</td>
</tr>
<tr>
<td>GPU GFLOPS</td>
<td>16 GFLOPS</td>
<td>12 GFLOPS</td>
<td>3 TFLOPS</td>
</tr>
</tbody>
</table>

Tegra 2 Mobile GeForce

- Separate vertex and pixel shaders
  - 4 of each, each capable of 1 multiply-add /clock
- Pixel, texture, vertex, and attribute caches
  - Reduce memory transactions
  - Pixel cache useful for UI components
- Memory controller optimizations
  - Arbitrate between CPU & GPU requests
  - Reorder requests to limit bank switching
NVIDIA Tegra 3 (Kal-El)

- Expanded Mobile GeForce
  - 4 vertex and 8 pixel shaders
- 4-PLUS-1 architecture

PowerVR SGX

- TA (Tile Accelerator) – store scene data and split up screen into tiles
- ISP (Image Synthesis Processor) – perform Hidden Surface Removal with z-testing
- TSP (Texture and Shading Processor) – run pixel shader

PowerVR SGX Series5XT

- Used in Apple A5, A5X
- Unified shader architecture (called USSE2)
- Tile based deferred rendering (TBDR)
  - Will cover in more detail next week
- Multi-core architecture
Mobile GPU Families

- Qualcomm Adreno
  - Unified shaders, 4-wide SIMD
  - Immediate mode with early-z
- Imagination Technologies’ PowerVR SGX Series5XT
  - Unified shaders, 4-wide SIMD
  - Tile based deferred rendering
- NVIDIA Mobile GeForce
  - Separate vertex (4) & pixel (8/12) shaders, scalar
  - Immediate mode with early-z
- ARM Mali
  - Separate vertex (1) & pixel (4) shaders, 4/2-wide SIMD
  - Immediate mode with early-z

Demands for Mobile

- Higher screen resolutions
  - Requires more memory bandwidth
  - Pixel count growing higher than geometry?
- Longer battery life
- Higher quality mobile gaming

Case Study: the new iPad

- Screen resolution of 2048x1536
  - Quadruple the pixels of previous 1024x768 version
  - Higher than nearly all desktop and laptop displays
- Battery life approximately equal to previous version
- Gaming performance?

iPad Gaming Performance

Image from AnandTech
What will the future bring?

- GPU Compute
  - PowerVR SGX Series5XT OpenCL capable, but no drivers
  - Could do compute the old-fashioned way with GLSL
  - Direct3D 11 means Compute Shader support
- PowerVR Series6 press release suggests 100-1000 GFLOPS
- Kepler-based GPU coming to a super phone near you?