Multimedia in Mobile Phones

Architectures and Trends
Lund 091124
Presentation

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- Working with multimedia hardware (graphics and displays) at ST-Ericsson (former Ericsson Mobile Platforms) since 2005.
- Worked with low power implementation of digital signal processing algorithms as PhD student at Linköping University. Graduated in 2005.
Outline

• Some perspective on mobile phone development
• Silicon technology development
• Mobile platform architectures
• Multimedia hardware components
• Conclusions
Some perspective on mobile phone development
Some perspective

- Speech (Fixed Telephony) 1876–
- Speech (Wireless Telephony) 1985–
- Text messaging 1995 –
- Image messaging 2001–
- Video Telephony 2003 –
- Graphics Hardware 2006 –

“richness”

~1876

Speech (Fixed-line)
~ the last 130 years

~1985

Speech (Wireless)
~ last 25 yrs

~2006

Text Messaging
~ last 15 yrs

Image messaging
~8 yrs
Video telephony
~6 yrs

HW Gfx
~ 3 yrs
Graphics Development in Mobile Phones

- Ericsson/Sony Ericsson phones used as examples
  - This can be mapped to, more or less, all phone vendors

<table>
<thead>
<tr>
<th>Year</th>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>T28</td>
<td>Monochrome display</td>
</tr>
<tr>
<td>2001</td>
<td>T68</td>
<td>Display 101*80 pixels, 256 colors</td>
</tr>
<tr>
<td>2003</td>
<td>T610</td>
<td>Display 160*128 pixels, 65536 colors</td>
</tr>
<tr>
<td>2006</td>
<td>W900</td>
<td>One of the first phones with graphics hw acceleration</td>
</tr>
<tr>
<td>2007</td>
<td>W880</td>
<td>JSR 184 (OES 1.0), QVGA display (320*240)</td>
</tr>
<tr>
<td>2009</td>
<td>Satio</td>
<td>Open GL ES 2.0, nHD display (640*360)</td>
</tr>
<tr>
<td>2010</td>
<td>X10</td>
<td>Android, OpenGL ES 2.0 HW, WVGA display (854*480)</td>
</tr>
</tbody>
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Moore’s Law

• “The complexity for minimum component costs has increased at a rate of roughly a factor of two per year. Over the longer term, the rate of increase is a bit more uncertain, although there is no reason to believe it will not remain nearly constant for at least 10 years“

  Gordon E. Moore, 1965

  • The number of transistors that can be placed on an integrated circuit of a certain area at a certain year

- Today we have enough silicon area to develop complex System-on-Chip (SoC) for mobile platforms.
  - Several CPUs/DSPs, access hardware (Edge, WCDMA, LTE), hardware accelerators for various multimedia functionality (graphics, video, imaging).
Can we take full advantage of new silicon technologies?

- The development costs/times increases as the technology develops
  - Time-to-market critical
  - Cost is a major driving force. 1 dollar saved on each silicon die is a lot of money on a market where total yearly sales are in the order of 1 billion units

- What about power consumption?
  - For example, QVGA→VGA display resolutions increases the fill rate requirements by a factor 4
  - End-user expects, at least, the same battery life-time as in previous products
  - No fan for cooling the mobile phone...
  - More power efficient technologies must be used!
  - Power-efficient software is one key factor to reduced power consumption
Mobile Architectures
Mobile Architectures – History and Trends 1(2)

• Step 1 – Multimedia centric DSPs
  • Mainly for audio, also used for video, imaging
  • Register based (load–store), cached, VLIW (static superscalar), SIMD, smarter DMA, ..

• Step 2 – Generic (embedded) CPUs
  • More advanced architectures (similar to PC CPU evolution)
  • Support for higher frequencies
  • Getting more done per cycle (e.g. deeper pipelines, branch prediction, SIMD, ..)
  • Improved support for multimedia (DSP ext., SIMD, floating point)
  • Larger register banks (enables larger loops at max performance –> good for multimedia)
Mobile Architectures – History and Trends 1(2)

• **Step 3 – Dedicated hardware accelerators**
  - Increasingly important the coming years (as long as CPUs/DSPs does not provide enough performance)
  - Graphics, video, audio, display, camera
  - Pros: silicon efficient, performance, more power efficient
  - Cons: less flexible, often “fixed” functionality

• **Step 4 – Memory sub-systems increasingly optimized for multimedia**
  - When processing power increases, memory bandwidth becomes bottleneck
  - Multimedia processing is bandwidth hungry (especially graphics and video)
  - More advanced caches and on-chip RAM structures (L2, L3)
  - More advanced bus-systems and associated components (e.g. memory- and DMA-controllers)
  - Wider and faster internal and external data busses
Hardware block diagram for a mobile platform

- U8500 – coming mobile platform from ST-Ericsson
Multimedia Performance in U8500

- Dual camera support with Integrated ISP (18 Mpixel and 5 Mpixel)
- Full HD 1080p camcorder, multiple codecs supported (H264 HP, VC–1, MPEG–4)
  - HD 1080p – 1920×1080 i.e. 2,073,600 pixels/frame. At 30 fps this means 62 Mpix/s. If 16 bpp is assumed, the memory bandwidth for video record only is 124 MB/s.
- Dual display support up to XGA. Simultaneous dual display support
  - XGA – 1024×768 i.e. 786432 pixels/frame. For a 16 bpp frame buffer and 30 fps refresh rate the memory bandwidth required to refresh the display 47 MB/s
  - With two XGA displays the bandwidth is 94 MB/s
  - The two displays can be a complex UI or a 3D game. Then the bandwidth numbers increases dramatically
- High performance 3D graphics, support for OpenVG 1.1 and OpenGL ES 2.0
  - ARM Mali 400 GPU
Multimedia Hardware Components
Mobile CPU development

• ARM dominates the mobile phone market
  • ARM9
    • Most common processor in mobile phones today.
    • Clock frequencies up to 400 MHz.
  • ARM Cortex A8
    • New CPU architecture
    • Increased clock frequency compared to ARM9 – 600 MHz to 1GHz
    • Currently used in many smartphones on the market.
    • Includes a SIMD vector processing unit – NEON
      • Mainly aimed at multimedia processing
  • ARM Cortex A9
    • Evolution of A8
    • Can be used as a multicore CPU – using up to 4 cores

• Intel targets the mobile domain with the Atom CPU
  • What will happen in the smartphone segment (dominated by ARM) and in the netbook segment (dominated by Intel)?
Phone memory systems

Shared RAM configuration

Congestion: Many subsystems wants access at the same time
Memory trends

• On-Chip Level-2 caches are often used
  • Make sense when the CPUs process data faster than external RAMs can deliver

• Larger and faster on-chip RAMs
  • However, every byte of on-chip memory comes with a silicon cost.

• Larger and faster external RAM
  • 16 –> 32 bit wide data bus
  • Mobile DDR, Mobile DDR2 interfaces
  • Memory bandwidths will go up
    • Mobile SDR SDRAM 100 – 300 MB/s
    • Mobile DDR SDRAM 400 – 1600 MB/s
    • Mobile DDR2 1.6 – 4 GB/s

• Latency for external memory accesses will increase
  • More complex bus structures –> higher latency
  • Latency tolerant processing subsystems are required

• Burst accesses important
  • Make sure you read and write bursts, i.e. several bytes of data, e.g. 8 – 32 bytes at once
Mobile phone graphics 1(3)

- 3D graphics in the PC world
  - "OK" to burn power
    - Wired power supply
    - Efficient cooling
  - "Extreme" memory systems
    - Dedicated graphics memories with high bandwidth interfaces
  - "Extreme" parallellism and chip sizes
    - 4.3 billion 40nm transistors, 3200 processing units (ATI Radeon™ HD 5970)
- GPUs (Graphics processors)
  - Programmable graphics
  - Well established now
  - General purpose computing
- How is this mapped to the mobile space?
Mobile phone graphics trends 2(3)

• Mobile phone graphics heavily influenced by PC graphics
  • Possibility to leapfrog several evolutionary steps
  • About 4 years from fixed function pixel pipelines to programmable pixel pipelines in mobile phones.

• Actually, the latest mobile graphics IP cores have feature set similar to ~2 year old ”Best-in-class” PC GPUs
  • Not (by far) as much parallelism (high-end PC graphics chips are way larger than our entire BB chip)
  • Not (by far) the same (extreme) memory systems
  • Not (by far) the same performance levels

• Programmable mobile GPUs (OpenGL ES 2.0) are available in phones on the market today (for example Sony Ericsson Satio, iPhone 3GS)
  • Learn how to program shaders!
  • Many effects and tricks from PC graphics can be used
  • General purpose computing on GPU (GPGPU)
  • OpenCL is a new Khronos API for parallel programming. Will probably end up in the mobile world as well
Mobile phone graphics trends 3(3)

- Memory bandwidth is the #1 gating factor for performance
  - Memory bandwidth is a shared resource

- Improved bandwidth efficiency – key concern
  - Texture compression
  - Z-buffer compression
  - Color buffer compression
  - Zmin/Zmax culling
  - Deferred shading (shade only visible primitives)
  - Tiling architectures are popular

- In general for mobile graphics
  - Save bandwidth!!!
  - Apply compression whenever possible
  - Render only visible stuff
  - Do it smarter and more efficient
  - Room for new innovative algorithms and architectures
Software platforms

- Traditionally the mobile OS has been proprietary and not easily available for developers
  - The application development has more or less been controlled by the hand-set manufactures
- Today there is a strong drive towards open operating systems for mobile phones
  - Open in terms of that they are available for application developers
  - Android from Google, iPhone OSX, Symbian, Windows Mobile
  - A great opportunity for application development!
Conclusions

- Multimedia is one of the driving forces for mobile phone development today
  - The feature and performance requirements are closing in on the PC market
- Two major hardware challenges moving forward
  - How do we obtain enough performance with the memory bandwidth available?
  - How do we manage the power consumption with increasing performance?
- The growing mobile OpenOS market gives you the opportunity to develop applications for your mobile phone
LET'S CREATE IT

THANK YOU