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Multimedia in Mobile Phones

Architectures and Trends

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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

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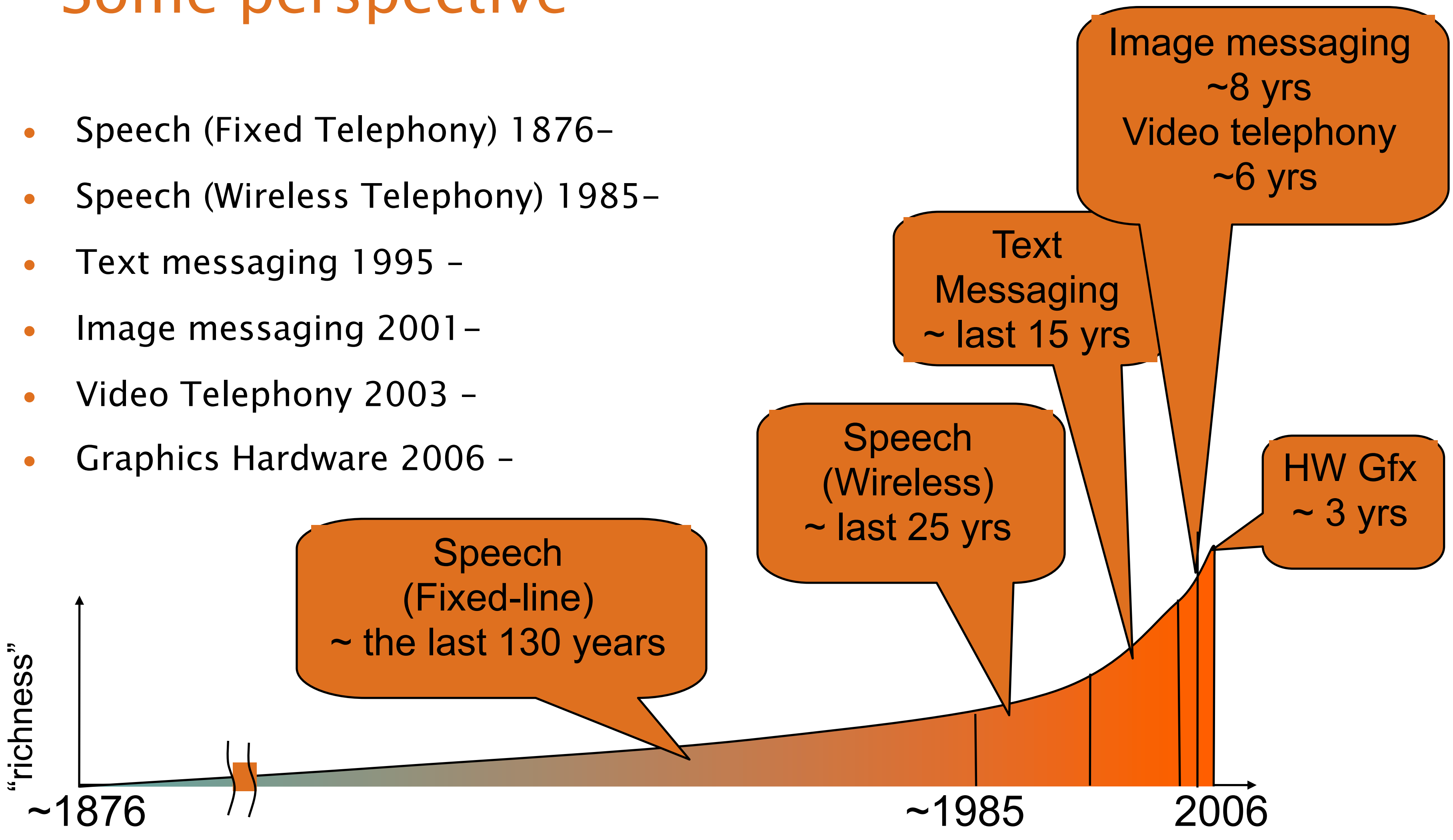
Some perspective

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



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Graphics Development in Mobile Phones

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

T28
Monochrome display

T68
Display 101*80 pixels
256 colors

T610
Display 160*128 pixels
65536 colors

W900
One of the first phones with graphics hw acceleration

W880
JSR 184 (OES 1.0)
QVGA display (320*240)

Satio
Open GL ES 2.0
nHD display (640*360)

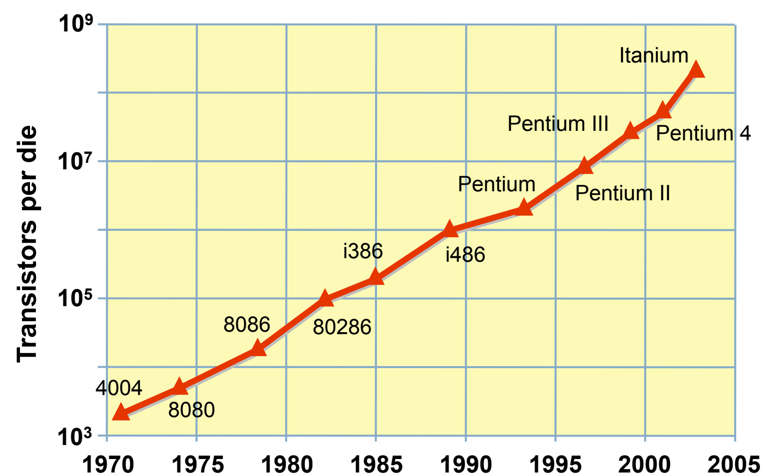
X10
Android
OpenGL ES 2.0 HW
WVGA display (854*480)

1999 — 2001 — 2003 — 2006 — 2007 — 2009 — 2010

Silicon Technology

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)

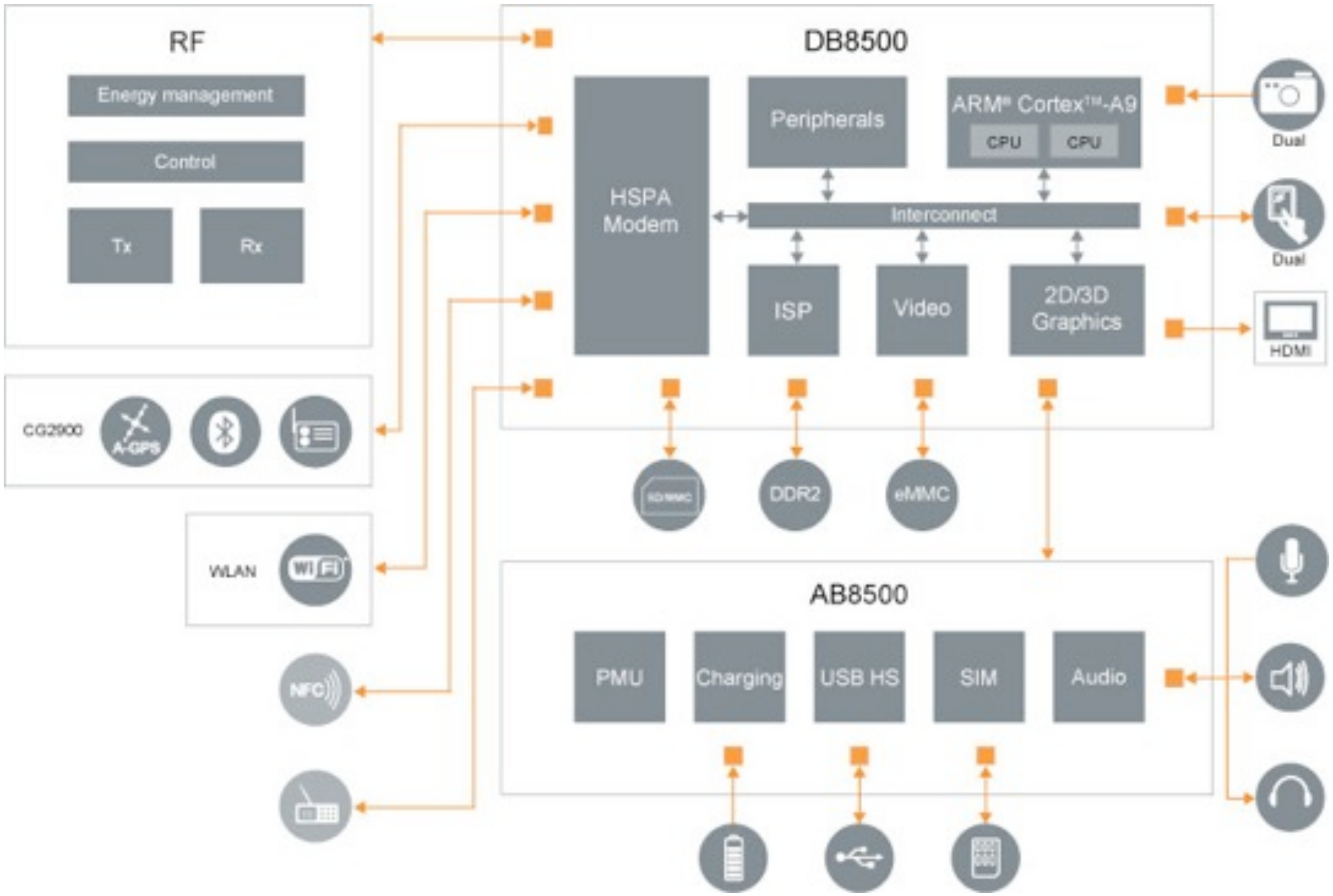
- Step 1 – Multimedia centric DSPs
  - Mainly for audio, also used for video, imaging
  - Register based (load-store), cached, VLIW (static superscalar), SIMD, smarter DMA, ..
- Step 2 – Generic (embedded) CPUs
  - More advanced architectures (similar to PC CPU evolution)
  - Support for higher frequencies
  - 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

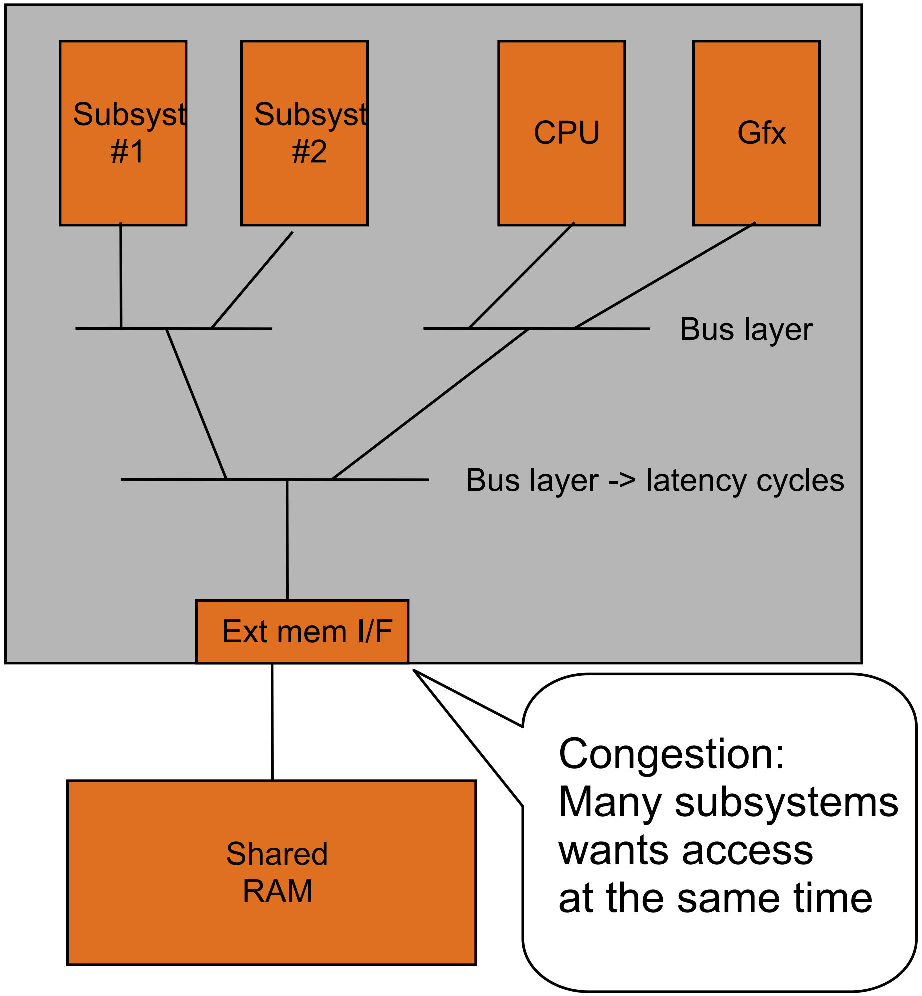
Multimedia Hardware Components

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



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 processong 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 availible 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 architecures 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 availible 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 availible 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 availible?
  - 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

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