Intel® Atom™ Microarchitecture for Tablets and Smartphones

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AAF 2012
Agenda

• Medfield / Clovertrail Overview - Intel® Platform for Smartphones and Tablets
• Power & Battery Life
• Platform Performance
• Next Generation Platform
• Q&A
Medfield Platform Objectives and Innovations

Intel’s Purpose-built Platform for Smartphones & Tablets

• Leverage Intel® Architecture and Process Technology – 32nm SoC
• Drive Low Power Standby and Active Operation – Fine grain Power Management, LP IA Audio, PnP Tuning
• Fit in Aggressive Smartphone & Tablet Form Factors – Xolo*, Orange*, Motorola, Lenovo, Samsung, Acer ...
• Single/Multi-Thread CPU Performance – Burst Mode, Intel® Hyper-Threading Technology, 2GHz operation; Dual core on Tablets
• Advanced Media Performance (Graphics, Video, Camera) – HD 1080p Decode, Encode, Fast Camera with burst mode

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Medfield Block Diagram

SOC with Hi-k 32nm Process Technology

- CPU
- L2 $ 512KB
- LP-DDR2 Ctrl

- 2D/3D Graphics
- Video Decode 1080p30
- Video Image Enhance
- Display Ctrl 3 Pipes

- Image Signal Processor Programmable
- Low Power Audio Engine
- Security Programmable Execution Environment & Crypto Engine

- I/O
- MIPI-HSI SPI UART ULPI
- Video Encode 1080p30

- I/O
- LPDDR2 eMMC MIPI-DSI HDMI 1.3a MIPI-CSI UART

- TI WiFi & BT GPS
- SIM Card
- XMM™ 6260 HSPA+ Modem
- USB OTG 2.0
- MSIC VRs, Audio CODEC Display Support

- LPDDR2
- eMMC
- SD/MMC
- Internal Disp
- PMU
- HDMI Display
- Primary Camera: 8MP; 15fps, 1080p
- Secondary Camera: 1.3MP, 1080p

Medfield = Intel® Platform for Smartphones and Tablets

AAF 2012
Benefits of Intel Architecture

- Intel Architecture (IA) implemented with multiple microarchitectures to deliver great performance at low power
- Intel Architecture (IA) is one of the most widely supported Computing platforms – significant tools and eco-system advantage
- Intel maintains a competitive position in multiple processor and multi-core architecture – running on leading operating systems
- Intel Technology – fast generational innovations – provides power, performance and integration advantages for SoC’s

*Intel Architecture enables great Smartphone and Tablet Platforms*
Penwell SoC Package Size

- **Memory Peak Bandwidth**
  - 6.4GB/s @ 800MT/s
  - Channels and ranks

- **Dual 32 bit channels**
  - Supports 1 or 2 ranks per channel

- **Memory Size and Density**
  - Supports total memory size of 128MB, 256MB, 512MB and 1GB per channel
  - Supports 1Gb, 2Gb and 4Gb chip densities

- **Other Features**
  - Aggressive power management to reduce power consumption
  - Proactive page closing policies to close unused pages
  - Supports different physical mappings of bank addresses to optimize for performance

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Package-on-Package (POP)
- 12 x 12 mm PoP FCMB4 - 32nm
- Non PoP SoC < 0.8 mm
- PoP z height < 1.4mm
- OEM/ODM can solder up to 2 GB of LPDDR2 memory on top of SOC
## Low Power Platform Progression

<table>
<thead>
<tr>
<th></th>
<th>Moorestown (45nm)</th>
<th>Medfield (32nm)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Board size</strong></td>
<td>5,000mm²</td>
<td>4,150mm²</td>
<td>↓ 17%</td>
</tr>
<tr>
<td><strong>Standby power</strong></td>
<td>21mW</td>
<td>14mW</td>
<td>↓ 33%</td>
</tr>
<tr>
<td><strong>Browsing power</strong></td>
<td>1.2W</td>
<td>0.85W</td>
<td>↓ 29%</td>
</tr>
<tr>
<td><strong>Video</strong></td>
<td>+ 720p encode</td>
<td>+ 1080p encode</td>
<td></td>
</tr>
<tr>
<td><strong>Camera</strong></td>
<td>5 mega-pixel</td>
<td>up to 16 mega-pixel</td>
<td></td>
</tr>
<tr>
<td><strong>Graphics</strong></td>
<td>800 MPPS</td>
<td>2,000 MPPS</td>
<td>↑ 250%</td>
</tr>
</tbody>
</table>
Designed for Tablets - Z2760

(SoC - Intel® Atom™ Processor)

- Dual Core CPU w/Intel® HT Technology
- 2X L2 Cache 512KB
- LPDDR2 Control
- Video Encode and Decode (1080p)
- Image Signal Processor
- Security

I/O:
- HDMI
- USB 2.0
- SDIO 2.0
- eMMC
- I2C

I/O:
- SPI
- MIPI-DSI
- MIPI-CSI
- MIPI-HSI
- UART
- HS-UART

*Intel® Hyper-Threading Technology (Intel® HT Technology)
POWER &
BATTERY LIFE
Power Breakthroughs Enabled By...

**PROCESS LEADERSHIP**

Intel® Hi-k 32nm Low Power (LP) SoC Process

**ARCHITECTURAL ENHANCEMENTS**

New Intel® Standby SoC Power States

Next Gen Intel® OS Power Management

Handheld I/O

Enhanced Intel® SpeedStep® Technology

Hardware Accelerators

**DESIGN TECHNIQUES**

Distributed Power Gating

Ultra Low Power (uLP) ATOM™ core enhancements

Dedicated Mixed Signal IC (MSIC)
The OS is responsible for identifying when the processor needs to be in a certain C state and requests the processor to enter that state.
New Platform Level: “S0iX” Ultra Low Power States

**S0i1**
- Used during idle (e.g. home screen, web browsing)
- Ultra Low Power: \( \text{mW} \)
- Entry-Exit Latency: \( \mu\text{s} \)

**S0i3 / S3**
- Used when NOT interacting with the device (e.g. standby mode)
- SoC power: \( \mu\text{W} \)
- Entry-Exit Latency: \( \text{ms} \)

### Achieves Ultra Low Power States with Best-in-Class Latency
Intel® OS Power Management (OSPM)

- Pervasive Power Management
  - Integrated PMU
  - Dedicated Power Delivery IC
  - Active management through HW, FW, SW

- Software-Directed
  - Operating system power management
  - Manages all hardware capabilities

- Fine Grain Power Management
  - 13 rails for IO & logic voltages
  - 45 Power islands for sub-systems
  - Aggressive power and clock gating
  - Integrated clocks and VR power down

OSPM Directs Entire Platform to Lowest Power State
Active system looks like this:

- **Security Engine**
- **Power Manager**
- **Low Power Audio**
- **CPU w/ 512KB L2$**
- **2D/3D Graphics**
- **Image Signal Processor**
- **Video Encode/Decode (1080p30)**
- **Display Controller (3 pipes)**

CPU Active
CPU Off

CPU is now off!

CPU w/512KB L2$
S0i1 System State

- Security Engine
- Power Manager
- Low Power Audio
- Storage
- CPU w/512KB L2
- 2D/3D Graphics
- Image Signal Processor
- Video Encode/Decode (1080p30)
- Display Controller (3 pipes)

S0i1 - low activity
S0i3/S3 System State

Standby State – just waiting for wakes
Penwell CPU Dynamic Range

Wide Dynamic Range & Fast Exit Latencies = Big Energy Savings

Core Freq = 100MHz
Power: ~50mW

Core Freq = 600MHz
Power: ~175mW

Core Freq = 1.3 GHz
Power: ~500mW

Core Freq up to 2.0 GHz
for bursty workloads
Power: ~750mW

Core/L2$ Power Is ~Zero
CPU State Saved in SRAM <100 uS Exit Latency

Fine-grained power management through dynamic voltage & frequency scaling

Power assumptions: Tj=70C. Steady State Worst Case ST App Power Projected on Intel 32nm process

Intel

Fixed Workload

Bursty Workload

Competition

HFM

Ultra-LFM

Burst

IMPACT
Battery Benchmarks

Battery Life - Browsing

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At least based on this data, it looks like Intel is the closest to offering a real competitor to Apple’s own platform from a power efficiency standpoint. We’re a couple quarters away from seeing the next generation of mobile SoCs so anything can happen next round, but I can’t stress enough that the x86 power myth has been busted at this point.

- Oct 16, 2012
The x86 power myth is finally busted. While the X900 doesn’t lead in battery life, it’s competitive with the Galaxy S 2 and Galaxy Nexus. In terms of power efficiency, the phone is distinctly middle of the road - competitive with many of the OMAP 4 based devices on the market today. If you’ve been expecting the first x86 smartphone to end up at the bottom of every battery life chart, you’ll be sorely disappointed.

This was another area of strength for Intel. In our standard battery test, which cycles through websites and videos with the screen set to 60 percent brightness, the RAZR M lasted seven hours and 22 minutes, while the RAZR i lasted a full eight hours and 42 minutes. Where the phones truly differ, however, is in standby time. The RAZR i managed to last 72 hours of regular use, including pushing email to two separate accounts, with 12 percent of its battery remaining. In contrast, the RAZR M will get you a full day’s normal usage, but not much more. It’s clear that Intel’s chip is far more frugal with power than the dual-core Snapdragon S4.
PERFORMANCE
Intel® Burst Performance Technology

- Takes advantage of thermal headroom (up to $T_{j\text{-max}}$ or $T_{\text{skin}}$) to deliver highest frequencies

- Races to Idle once “burst mode” performance is not needed

“Performance On-Demand” without Impacting Thermal Design
## Browser_R Results Summary

<table>
<thead>
<tr>
<th></th>
<th>P0</th>
<th>600 MHz</th>
<th>900 MHz</th>
<th>1500 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>1x</td>
<td>1.5x</td>
<td>2.5x</td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td>1x</td>
<td>1.41x</td>
<td>2.24x</td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>1x</td>
<td>1.29x</td>
<td>1.81x</td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>1x</td>
<td>0.92x</td>
<td>0.81x</td>
<td></td>
</tr>
</tbody>
</table>
Intel® Hyper-Threading Technology Improves Efficiency

- Adding threads to an in-order micro-architecture improves perf/power efficiency, perf/area efficiency and performance scalability.
- Non-stall based pipeline designed to switch threads every clock cycle.

**Performance**

- EEMBC (2 copies) SPECint2000_rate
  - +36%
  - +39%

**Power**

- EEMBC (2 copies) SPECint2000_rate
  - +19%
  - +17%

*Data from Bonnell-Silverthorne silicon measurements. Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance of Intel products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance.*
Benefits of Intel® Hyper-Threading Technology

Execution Resource Utilization

First Thread/Task

Second Thread/Task

Both Threads/Tasks without Intel® Hyper-Threading Technology

Both Threads/Tasks with Intel Hyper-Threading Technology

Time

Time saved
Performance Benchmarks

“With the Xolo X900, Intel has officially put the ARM manufacturers on notice....it’s downright impressive”

April 25, 2012

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**Google Octane Benchmark v1**

- **Apple iPhone 4S**: 757
- **Motorola Droid RAZR M (Snapdragon S4)**: 1098
- **HTC One X (Tegra 3)**: 1131
- **HTC One X (Snapdragon S4)**: 1280
- **Apple iPhone 5**: 1672
- **Motorola RAZR (Atom)**: 2048

**Google V8 Benchmark - Version 7**

- **Apple iPhone 4S**: 718
- **Motorola Droid RAZR M (Snapdragon S4)**: 1162
- **HTC One X (Tegra 3)**: 1162
- **HTC One X (Snapdragon S4)**: 1222
- **Apple iPhone 5**: 1507
- **Motorola RAZR (Atom)**: 2209

*Motorola RAZR (Atom): 14455.3
Motorola Droid 2: 10618.6
HTC One X (Snapdragon S4): 22171.3

*Other names and brands may be claimed as the property of others.*
## Z2760 Performance - TouchXPRT 2013

<table>
<thead>
<tr>
<th></th>
<th>Photo Enhance</th>
<th>Photo Exper</th>
<th>Video Transcode</th>
<th>MP2 Transcode</th>
<th>Photo Slideshow Creation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel Atom Z2780</td>
<td>210.83</td>
<td>75.93</td>
<td>53.91</td>
<td>98.66</td>
<td>85.81</td>
</tr>
<tr>
<td>MS Surface (Tegra 3 1.3GHz)</td>
<td>306.12</td>
<td>116.36</td>
<td>87.27</td>
<td>160.99</td>
<td>125.06</td>
</tr>
<tr>
<td>Asus Vivo Tab RT (Tegra 3 1.3GHz)</td>
<td>312.14</td>
<td>109.89</td>
<td>89.69</td>
<td>155.84</td>
<td>122.65</td>
</tr>
</tbody>
</table>

*On the user experience side alone, the Clover Trail tablet is noticeably quicker than Surface…*  

October 23, 2012

*Other names and brands may be claimed as the property of others.*
Smartphones and Tablets
Medfield

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Rich Portfolio of Form Factors

Intel® Atom™ Processor-based tablets/convertibles for Windows® 8

A few systems that have already been announced:

- Lenovo* Think Pad 2
- Asus* Vivo Tab
- Samsung* ATIV Smart PC†

And More to Come... Great Choices for Work and Play
Intel® Atom™ Processor Tablet Platform

Clover Trail

**Medfield**
*Intel® Atom™ Z2610*
*Up to 1.6 GHz (Burst)*

**Clover Trail**
*Intel® Atom™ Processor*
*Up to 1.8 GHz (Burst)*
*Dual Core w/ 2X CPU Performance*

**Bay Trail**
*New microarchitecture*
*22nm*
Intel® Atom™ Processor Smartphone Platform
Clover Trail+

Medfield
Intel® Atom™ Z2460
Up to 2.0 GHz (Burst) Processor

Clover Trail+
Intel® Atom™ Z2580
Dual Core w/ 2X CPU & Graphics Performance

Next Generation...
New microarchitecture 22nm
Summary

• Intel® Architecture using Intel® Burst Technology and Intel Hyper-Threading Technology delivers high performance on demand with energy saving.

• OS driven fine-grain power management enables Medfield & Clovertrail platforms to deliver competitive battery Life.

• Intel’s 32nm process technology enables us to integrate and deliver high performance CPU and Media in Smartphone and Tablets.

• Next Generation Platforms will continue to leverage Intel Process Technology and Microarchitecture to deliver best user experience.
Backup
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