Hotchips 2013: Clovertrail+ Smartphone SoC Platform

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Talk Outline

- Clovertrail+ Overview
- Generational improvements
- Key enhancements – media, imaging, power management
- Power and performance
Overview: Intel® Atom™ Clovertrail+ SoC

Intel 32nm High-K + metal gate process
14x14mm coPOP package
CPU ISA compliant with Core 2 processors: SSE2, SSE3, SSSE3
A Look Inside the Clovertrail+ SoC

- **Intel® Atom™ CPU**: 512KB L2 Cache
- **North SoC Interconnect**: SGX544MP2, 533 MHz
- **Integrated Security Engine**: Crypto offload, secure boot
- **Video Decoder**: Hardware accelerated 1080p Video Decode and Encode of all common formats (e.g. H.264, VC1, MPEG2)
- **Video Encoder**: Hardware accelerated 1080p Video Encode
- **Video Decoder**: Hardware accelerated 1080p Video Decode
- **Integrated Audio DSP**: For low power audio playback
- **Low Power IOs**: Silicon Hive fully programmable ISP, 1080p, 3A, dual camera, still image capture
- **Memory Controller**: LPDDR2
- **2 GHz, Dual Core with Hyper-threading, 1MB total L2 Cache, Frequency Scaling**: 2-Channels x32b, 2 ranks/ch, 533MHz, 8.2GB/s

**Intel® Atom™ CPU**: 512KB L2 Cache
- **Memory Controller**: LPDDR2
- **2-Channels x32b, 2 ranks/ch, 533MHz, 8.2GB/s**: A Look Inside the Clovertrail+ SoC
## Platform Generational Improvements

<table>
<thead>
<tr>
<th></th>
<th>Medfield Phone</th>
<th>Clovertrail+ Phone</th>
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</thead>
<tbody>
<tr>
<td><strong>CPU</strong></td>
<td>Intel® Atom™ 1 core 2 threads 2GHz (Intel Atom Z2480)</td>
<td>Intel Atom 2 cores 4 threads 2GHz (Intel Atom Z2580)</td>
</tr>
<tr>
<td><strong>Memory, Storage</strong></td>
<td>1GB LPDDR2 @ 800MT/s 64GB eMMC 4.3</td>
<td>2GB LPDDR2 1066MT/s with OOO optimizations 256GB eMMC 4.41</td>
</tr>
<tr>
<td><strong>Graphics</strong></td>
<td>SGX 540 @ 400 MHz</td>
<td>SGX 544MP2 @ 400MHz (533MHz burst)</td>
</tr>
<tr>
<td><strong>Video Decode</strong></td>
<td>Standard codecs: H.264, MPEG4, VC1, DivX, VP6</td>
<td>Added VP8, Real Video, Sorensen</td>
</tr>
<tr>
<td><strong>Camera/Imaging</strong></td>
<td>8 MP with AF/LED Flash, 1080p30 video recording, 1.3 MP front facing</td>
<td>13 MP with AF/LED Flash, 1080p30 video recording, 2 MP front facing</td>
</tr>
<tr>
<td><strong>Display</strong></td>
<td>MIPI DSI up to 700Mbps/lane. Up to 13x7 panels</td>
<td>MIPI DSI up to 1Gbps/lane. Up to 19x12 panels concurrent with HDMI</td>
</tr>
<tr>
<td><strong>IOs</strong></td>
<td>Standard IOs</td>
<td>Additional ULPI, PWM, I²S</td>
</tr>
<tr>
<td><strong>Cellular Modem</strong></td>
<td>Intel® XMM™ 6260 - HSPA+ 21Mbps</td>
<td>Intel XMM 6360 (HSPA+ 42 Mbps), LTE modem in 2013</td>
</tr>
</tbody>
</table>
Clovertrail Generation Derivatives

- Clovertrail ‘twins’
  - Clovertrail: Win8 tablets
  - Clovertrail+: Android phones and tablets

- Project success drivers:
  - Started with solid Penwell baseline
  - Re-used >70% of the HW, FW and existing drivers
  - Intel was able to deliver 2 SoCs off the same base architecture

- Clovertrail+ delivers performance enhancements in same package and footprint
  - SGX544-MP2 (versus SGX545) – 4x GFLOPs, >3x Mtri/s, >2x Mpix/s, on-demand burst
  - Improved memory bandwidth and utilization
  - Improved fabric and uarch optimizations
Benefits Of Going To 2 Cores 4 Threads

• Going from Penwell to Clovertrail+, we go from 1 core, 2 threads to 2 cores, 4 threads
• Increases performance by adding logical cpu(s) on top of a physical core
  - Architectural state replicated per thread
  - Each thread presented as a core to the OS
  - 1 thread active – single thread uses all resources optimally
• Based on Simultaneous Multi-Threading (SMT)
  - Switch on Event (SoE) not efficient as pipeline flushed when swapping
    • Triggers on long latency operations given overhead
  - SMT interleaves multiple threads within pipeline
    • Superscalar in-order uarch benefit most
    • Supports thread switch every cycle
• SMT efficiency enables higher freq at same voltage
• 7-15% core area adder (excluding L2)
  • Much lower than multi-core
Clovertrail+ Memory/Media Performance Enhancements

- **Memory**
  - Improved QoS across concurrent memory accesses
  - Out-of-order transactions optimizing page accesses
  - Increased memory frequency from 400 to 533MHz LPDDR2 (2x32-bit)

- **Graphics**
  - GPU On-demand burst with CPU-GPU power sharing
    - Burst request by Graphics driver based on HW activity counters
    - PM unit manages DVFS; energy management framework ensures optimal burst states for GPU and CPU

- **Display**
  - Pipeline optimizations to support concurrent 19x12 MIPI DSI panel and 1080p30 over HDMI
  - WiDi stack optimized for latency and power with SoC accelerators
    - Clone mode end-to-end latency 60-80 msec for 1080p

- **Ultra low-power music playback** – MP3 playback <65mW platform power
Camera/Imaging Subsystem (CSS) Enhancements

- CSS includes programmable VLIW SIMD vector processor (pixel processing, multiple issue slots), scalar processor (control), DMA, MMU, local memory, CSI2 receiver
- Enhanced CSS firmware infrastructure supports zero shutter lag (ZSL), continuous viewfinder, Time Shift and multi-threading
- Integrated HDR
- Improved single-shot low light performance, faster AF
- 1080p Panorama
- Smart scene, smile and blink detection for smart shutter
Cheaper PMIC
Platform Arch enables OEM to choose Audio Codec and PHYs
Dynamic Power Management – S0ix/D0ix

- **S3** – Apps are frozen, drivers are suspended to D3

- **S0i3**
  - Apps acquire wake locks to prevent S3
  - Platforms enter S0i3 when all devices are in D0i3
  - When wake locks are released, Android PM pushes platform to S3, OS timers are disabled

- **S0**
  - User Activity, Incoming Call, etc.
  - Kernel Runtime PM framework allows drivers to do autonomous D0ix

- **Android S0ix**
Power Management in Action: CPU Active (S0)
Power Management in Action: CPU Idle (C6)
Power Management in Action: SOC Idle (S0i3)
CPU-GPU Dynamic Power Sharing

- PMIC
- Thermal Startup Configs
  - Chassis/Platform Thermal Config
  - Thermistor Value
- System Control Unit
  - GFX_Frequency
  - Skin_Thermal_State
  - Thermal Mgmt in IA
    - Skin_Thermal_State
    - Burst_Request
  - GFX Driver
    - Activity
    - GFX_Frequency
    - GFX_Frequency
  - CPU-GPU Thermal/Freq Manager
    - Skin_Thermal_State
    - Burst_Request

GPU (HW Activity Counters)

GFX Driver (Sets Boost Request based on Activity)
Generational Comparison: CPU Performance

AndEbench* is an Android benchmark that focusses on CPU performance, concentrating on integer operations.

Dual-core Clovertrail+ SoC supports up to 4 threads to provide higher CPU peak performance compared to Medfield on multi-threaded applications.

Clovertrail+ improves performance over Medfield by up to 2X

Note: Z2480 scores are measured on the Motorola RAZR i (Android 4.1.2) and Z2580 scores are measured on the Lenovo K900 (Android 4.2.1)
Generational Comparison: Graphics Performance

Kishonti’s GLBenchmark* 2.5.1 measures the performance of the graphics engine using complex 3D animations. The chart below uses the Egypt HD test in offscreen mode using a standard resolution of 1920x1080p.

Clovertrail+ SoC integrates the next generation graphics processor to greatly improve graphics performance over Medfield.

Clovertrail+ improves graphics performance over Medfield by up to 3X

Note: Z2480 scores are measured on the Motorola RAZR i (Android 4.1.2) and Z2580 scores are measured on the Lenovo K900 (Android 4.2.1)

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Smartphones are Multi-tasking Devices

Smartphones being more and more of the time for non-voice activities with significant amount of time spent on Gaming, Browsing, Utilities and Social Networking apps.

Top 10 features used - Global

- SMS: 93
- Take photos: 89
- Listen to music: 83
- Play games: 74
- Browse internet: 85
- Calendar: 65
- MMS: 67
- Instant messaging: 70
- Bluetooth: 60
- Social networking: 67
- Email: 64
- Apps: 65

D1: Feature usage
Base: Smartphone owners- Global 17372

Source: TNS Mobile Life Global Report 2013

Smartphones are multi-tasking devices as both web-based applications and Android store applications gain importance.
Fast Browser Performance

WebXPRT* from Principled Technologies measures Javascript / HTML5 Performance using web applications based on real-world usages.

Clovertrail+ leads the competition on real-world browser usages as indicated by the WebXPRT* scores.

Clovertrail+ provides great user experience for browser-based usages on a smartphone device.
Great Android User Experience

MobileXPRT* from Principled Technologies is a new benchmark that measures the real-world usage performance and end-user experience of Android devices.

![MobileXPRT* CP 2013 Scores](chart)

Source: Intel

Comp A and Comp B devices are two of the latest ARM-based premium Smartphones on the market today; Intel Smartphone is based on Clover Trail+ SoC.

Clovertrail+ is very competitive with other premium Smartphones on real-world media applications performed on Android devices.

Clovertrail+ provides great experience for typical end-user applications on Android devices.

Real-world usages in MobileXPRT:

- Detect Faces
- Apply Photo Effects
- Create Collages
- Create Slideshow
- Encrypt Content