Introducing 4th Generation Intel® Atom™ Processor, BayTrail, to Android Developers

Abstract

Intel has launched the 4th generation Intel Atom processor, code-named “BayTrail”. This latest Atom processor is a multi-core system-on-chip (SoC) that integrates the next generation Intel® processor core, graphics, memory, and I/O interfaces into one solution. It is also Intel’s first SoC which is based on the 22 nm processor technology. This multi-core Atom processor provides outstanding computing power and is more power efficient compared to its predecessors. Besides latest IA core technology, it also provides extensive platform features, such as graphics, connectivity, security, and sensors, which enable developers to create software with unlimited user experiences. This article focuses on BayTrail’s impact to Android, Intel’s enhancement to the Android architecture, and Intel’s solutions for Android developers.

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- Intel Tools for Atom-Based Android Platforms
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BayTrail SoC CPU Benefits

This section provides an overview of the BayTrail CPU capabilities. The new multi-core Intel® Atom™ SoC is powered by the Intel® Silvermont microarchitecture which delivers faster performance with low power requirements.

Faster Performance

- Quad core supports 4 cores/4 threads out of order processing and 2 MB of L2 Cache which makes the device run faster and more responsive by allowing multiple apps and services running at the same time.
- Burst technology 2.0 allows the system to tap extra core when necessary which allows CPU-intensive application to run faster and smoother
- Performance improved by using the 22-nm processor technology:
  - Maximizes current flow during ON state for better performance
  - Minimizes leaks during OFF state leading to more energy efficiency
- 64-bit OS capable

Efficient Power Management

- Supports dynamic power sharing between the CPU and IP (e.g. graphics) allowing for higher peak frequencies
- Total SoC energy budget is dynamically assigned according to the application needs
- Supports fine-grained low power states which provides better power management and leads to longer battery life
- Supports cache retention during deep sleep states leading to lower idle power and shorter wakeup times
- Offers more than 10 hours of active battery life
### Features

#### Processor Core
- Dual or Quad-core CPU
- Up to four IA-compatible low power Intel® processor cores — One thread per core
- Two-wide instruction decode, out of order execution
- On-die, 32 KB 8-way L1 instruction cache and 24 KB 6-way L1 data cache per core
- On-die, 1 MB, 16-way L2 cache, shared per two cores
- 36-bit physical address, 48-bit linear address size support
- Supported C-states: C0, C1, C1E, C6, C7
- Supports Intel® Burst Technology
- Higher core frequency

#### System Memory
- Supports LPDDR3-1067 (2 channel x 64-bits), 2GB or 4GB
- Supports DDR3L-RS 1333 (1 Channel x 64-bit), 2GB
- 64 bit data bus for each channel
- ECC supported in single channel mode only Supports LPDDR3 with 1066 MT/s data rate
- Supports x64 LPDDR3 SDRAM package data widths
- Supports x16 DDR3L-RS SDRAM device data widths
- Total memory bandwidth supported is 8.5GB/s (for 1066 MT/s single-channel) to 17.1GB/s (for 1066 MT/s dual-channel)
- Supports DDR3L-RS with 1333 MT/s data rate
  — Total memory bandwidth supported is 10.6 GB/s (for 1333 MT/s single channel)
- Supports different physical mappings of bank addresses to optimize performance
- Out-of-order request processing to increase performance
- Aggressive power management to reduce power consumption
- Proactive page closing policies to close unused pages
- Supports soldered down DRAM devices

#### Power Management
- ACPI 5.0 support
- Processor states: C0-C7
- Display device states: D0, D0ix – D3
- Graphics device states: D0, D0i3, D3
- System sleep states: S0, S0i1, S0i2, S0i3, S4, S5
- Support CPU and GFX Burst for selected SKUs
- Dynamic I/O power reductions (disabling sense amps on input buffers, tri gating output buffers)
- Conditional memory self-refresh during C2-C6
- Active power-down of display links
- Downloadable power management firmware

### Table1: BayTrail CPU Specs in a Nutshell

### BayTrail SoC Components Enhancements

In addition to the processor core, Intel has made many improvements to components on the SoC - such as graphics, imaging, audio, display, storage, USB, and security. These components enable developers to create innovative software on IA-based Android devices. The following is the highlight of each component.

- **Display**
  - Supports high-resolution display (up to 2560x1600 @ 60 Hz)
  - Retinal display capable
  - Supports dual display

- **Intel® Wireless Display (WiDi)**
  - Supports video up to 1080p/30 with 2 channel stereo
  - Content protection with HDCP2.1 (Widevine DRM)
  - Supports multi-task
  - Dual-screen apps are enabled
  - WFA Miracast certified

- **Graphics and Media Engine**
  - Based on Intel Gen7 HD graphic processor which provides amazing visuals
  - Supports graphics burst, Open GL ES 3.3, and hardware video codec acceleration of multiple media formats
  - Supports extensive video and display post-processing
- Stunning graphics with sharp and smooth HD video playback and internet streaming with more than 8-10 hours of battery life
  - **Image Signal Processor**
    - Supports ISP 2.0
    - Supports up to two cameras with 8 MP
    - Supports various imaging technologies, such as burst mode, continuous capture, low light noise reduction, video stabilization, 3A, and zero shutter lag.
  - **USB**
    - Supports USB 3.0
  - **Audio**
    - Low power audio engine
    - Supports multiple audio formats
  - **Storage**
    - Supports one SDIO 3.0 controller
    - Supports one eMMC 4.51 controller
    - Supports one SDXC controller
  - **Security**
    - Supports secure boot
    - Intel® Trusted Execution Engine (Intel® TXE)

### SoC Components

#### Display
- Supports 2 MIPI DSI ports with Stereoscopic 3D formats
- Support 2 DDI ports to enable eDP 1.3, DP 1.1a, DVI, or HDMI 1.4a
- Support 2 panel power sequence for 2 eDP ports
- Support Audio on DP and HDMI
- Supports Intel® Display Power Saving Technology (DPST) 6.0, Panel Self Refresh (PSR) and Display Refresh Rate Switching Technology (DRRS)

#### Graphics and Media Engine
- Intel's 7th generation (Gen 7) graphics and media encode/decode engine
- VED video decoder in addition to Gen 7 Media decoder
- Graphics Burst enabled through energy counters
- Supports DX*11, OpenGL 3.0 (OGL 3.0), OpenCL 1.2 (OCL 1.2), OpenGLES 2.0 (OGLES 2.0)
- GPU shader is capable of up to 8 gigaflops
- 4x anti-aliasing
- Full HW acceleration for decode of H.264, MPEG2, MVC, VC-1, VP8, MJPEG
- Full HW acceleration for encode of H.264, MPEG2, MVC
- Supports 2.0 Stereoscopic 3D Stretch
- Polyphase 8 tap scaling
- HD HQV
- Supports dual independent display
- Supports up to 25x16 resolution

#### Image Signal Processor
- Supports up to 2 cameras
- Supports Still pictures with up to 8 MP and video at 1080p60 capture
- Supports up to three MIPI CSI ports
- Support for up to 24MP sensors
- Supports Stereoscopic Video

#### USB
- Supports USB 3.0/2.0/1.1
- Implements xHCI software host controller interface
- One USB 3.0 Super Speed (SS) port
- Four ports multiplexed with EHCI controller that are High Speed/Full Speed (HS/FS)
- Internal Rate Matching Hub to support USB 1.1 to 2.0 devices
- Four Ports multiplexed with xHCI controller
- Enhanced EHCI descriptor caching
- Supports one USB 3.0 SS port with USB device compatibility
- Supports one ULPI port with HS/LS support

#### Audio
- Low power engine audio
- I2S and DDI with dedicated DMA
- MP3, AAC, AC3/DD+, WMA9, PCM (WAV)
BayTrail Improvement to Previous Atom Processor

Intel announced its first Atom processor for Android phones in 2012 - Z24XX, code-named “Medfield”, it was a single-core processor based on Intel's 32 nm processor technology. In the spring of 2013, Intel unveiled Medfield’s successor for phones and tablets, Z25XX series, code-named “CloverTrail+”, it was a dual cores processor based on Intel’s 32 nm processor technology. In the fall of 2013, Intel announced its latest Atom processor, Z3XXX BayTrail which is available in both dual and quad core and is based on Intel’s latest 22-nm processor technology. Many improvements have been made to BayTrail. The following table summarizes BayTrail’s improvement compared to its predecessor.

<table>
<thead>
<tr>
<th>Intel® Atom™ Processor Z25XX</th>
<th>Intel® Atom™ Processor Z3XXX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>32nm</td>
</tr>
<tr>
<td>Package</td>
<td>14x14</td>
</tr>
<tr>
<td>OS</td>
<td>Android</td>
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<tr>
<td>Cores/Threads</td>
<td>2 cores, 4 threads</td>
</tr>
<tr>
<td></td>
<td>In-order execution</td>
</tr>
<tr>
<td>Max Core Frequency</td>
<td>Up to 2.0 GHz</td>
</tr>
<tr>
<td>Graphics</td>
<td>SGX544MP2 (up to 533 MHz)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Display</td>
<td>Up to 1920x1200 Internal and 1080p/30 External</td>
</tr>
<tr>
<td>Memory</td>
<td>LPDDR2 (COPoP) 2x32 bit, up to 2GP</td>
</tr>
<tr>
<td>Memory BW</td>
<td>8.5GB/s</td>
</tr>
<tr>
<td>I/O and Storage</td>
<td>USB2.0, eMMC 4.41</td>
</tr>
<tr>
<td>Imaging</td>
<td>ISP 1.0</td>
</tr>
</tbody>
</table>

Table 3 BayTrail Enhancement from Previous Generation of SoC
BayTrail Variants for Android – Z36XXX and Z37XXX

The following table summarizes BayTrail variants for Android.

<table>
<thead>
<tr>
<th></th>
<th>Z3770</th>
<th>Z3770D</th>
<th>Z3740</th>
<th>Z3740D</th>
<th>Z3680</th>
<th>Z3680D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Process Technology</strong></td>
<td>22 nm</td>
<td>22 nm</td>
<td>22 nm</td>
<td>22 nm</td>
<td>22 nm</td>
<td>22 nm</td>
</tr>
<tr>
<td><strong>Number of Cores</strong></td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>L2 Cache</strong></td>
<td>2 MB</td>
<td>2 MB</td>
<td>2 MB</td>
<td>2 MB</td>
<td>1 MB</td>
<td>1 MB</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>Up To ~2.4 GHz</td>
<td>Up To ~2.4 GHz</td>
<td>Up To ~1.8 GHz</td>
<td>Up To ~1.8 GHz</td>
<td>Up To ~2.0 GHz</td>
<td>Up To ~2.0 GHz</td>
</tr>
<tr>
<td><strong>Memory Technology</strong></td>
<td>LPDDR3 1067 (Dual Channel)</td>
<td>DDR3L-RS 1333 (Single Channel)</td>
<td>LPDDR3 1067 (Dual Channel)</td>
<td>DDR3L-RS 1333 (Single Channel)</td>
<td>LPDDR3 1067 (Dual Channel)</td>
<td>DDR3L-RS 1333 (Single Channel)</td>
</tr>
<tr>
<td><strong>Peak Memory BW</strong></td>
<td>17.1 GB/s</td>
<td>10.6 GB/s</td>
<td>17.1 GB/s</td>
<td>10.6 GB/s</td>
<td>8.5 GB/s</td>
<td>10.6 GB/s</td>
</tr>
<tr>
<td><strong>Memory Capacity</strong></td>
<td>Up to 4 GB</td>
<td>2 GB only</td>
<td>Up to 4 GB</td>
<td>2 GB only</td>
<td>1 GB only</td>
<td>2 GB only</td>
</tr>
<tr>
<td><strong>Rec. Max Display Resolution</strong></td>
<td>25x16</td>
<td>19x12</td>
<td>25x16</td>
<td>19x12</td>
<td>12x8</td>
<td>19x12</td>
</tr>
</tbody>
</table>

Table 4 BayTrail SoC Variants

Intel Optimizations to the Android Software Stack

Android is Google’s open source Linux-based software stack developed for mobile phones and tablets. Google distributes the official code through the Android Open Source Project (AOSP) to the public. OEMs, who plan to release Android devices, can work with Google and modify the distribution to fit their platform needs. Android software stacks consists of:

- **Linux kernel** – contains device drivers and memory, security, power management related software.
- **Middleware** – contains native libraries required for the application development, for example media, SQLite, OpenGL, SSL, Graphics, and WebKit.
- **Android runtime** – contains Java core libraries and Dalvik virtual machine for running Java applications.
- **Android framework** – contains Java classes or APIs to create Android applications and services.
- **Applications** – contains Android applications.

Android version has evolved from its first release - CupCake, to its recent release - JellyBean (4.2), and to its current release - KitKat (4.4). BayTrail supports both JellyBean and KitKat distributions.

Intel has introduced many optimizations to the Android software stack for performance enhancement. Developers can create apps with snappy performance, smooth, and fluid user experiences.

Optimizations includes:

- Improvements that are made to ensure Dalvik apps run well on Intel processors
- Tools for NDK developers to compile native code (C/C++) for x86
- Optimizations to new web technologies such as HTML5 and Javascript
- Performance enhancement to Dalvik VM
- Optimizations to core libraries and the kernel by contributing to AOSP
- Device drivers that are validated and optimized for the x86 power and memory footprint
Intel Tools for Atom-Based Android Platforms

Google provides a suite of tools for developers to build and debug software on Android platforms. Developers are required to install the Android SDK and integrate it with their choice of IDE to build the software. Emulator, debugger, code optimizer, performance optimizer, and test tools are also available from Google.

Developer can start developing Android software with the initial tools described in the following list.

- **Android SDK** – SDK provides API libraries and developer tools that are necessary to build, test, and debug apps for Android. The SDK can be downloaded from [http://developer.android.com/sdk/index.html](http://developer.android.com/sdk/index.html)
- **Android Studio** – Latest Android development environment from Google, it provides another choice for an integrated environment for development and debugging with the Android SDK. Android Studio can be downloaded from [http://developer.android.com/sdk/installing/studio.html](http://developer.android.com/sdk/installing/studio.html)
- **Android NDK** – A toolset that allows developers to implement parts of an app using native-code languages such as C and C++. The NDK can be downloaded from [http://developer.android.com/tools/sdk/ndk/index.html](http://developer.android.com/tools/sdk/ndk/index.html)
- **Android Support Library** – Depending on what features you’re trying to develop, sometimes you may need to add an additional SDK or library to your development environment (for example, Google Ads SDK). Additional libraries/package can be downloaded from [http://developer.android.com/tools/support-library/setup.html](http://developer.android.com/tools/support-library/setup.html)
- **Android SDK & Platform Tools** – SDK tools are included with Android SDK. You can find a variety of tools to test, debug, and optimize your app. Check out this link, [http://developer.android.com/tools/help/index.html#tools-sdk](http://developer.android.com/tools/help/index.html#tools-sdk), for an introduction and usage of SDK tools (adb, monkey, traceview, emulator, proguard, sqlite3 ... etc)
In addition to Google’s Android tools, Intel also provides tools specifically for helping developers speed up their development for Atom-based Android platforms.

- **Intel® System Studio for Android** – An Intel integrated software tool suite that helps developers to accelerate time to market, strengthen system reliability, and boost power efficiency & performance. The Intel® System Studio for Android includes tools for CPU and SoC analysis for system bring-up, development, power and performance tuning of system software. Intel® System Studio for Android is currently available under NDA only. For more information, please contact Intel at intelsystemstudio@intel.com.

- **Beacon Mountain for Android** – A free tool that provides developers development environment setup and maintenance for creating native Android apps. Beacon Mountain can be downloaded from http://software.intel.com/en-us/vcsource/tools/beaconmountain

- **Intel® C++ Compiler for Android OS** – Intel C++ Compiler helps developers to improve the performance of their native Android apps by just compiling. Trial version of Intel C++ compiler can be downloaded from http://software.intel.com/en-us/c-compiler-android/

- **Android x86 Emulator System Image** – Enables developers to quickly test their Android apps on a virtual Android device based on Intel Architecture.

- **Intel® Hardware Accelerated Execution Manager** - Speeds up Android app emulation on a host machine when used with x86 emulator images. http://software.intel.com/en-us/articles/intel-hardware-accelerated-execution-manager/

- **Intel® USB Driver for Android Devices** – Enables IA-based Android device connectivity to your Windows-based host. USB drivers can be downloaded from http://software.intel.com/en-us/articles/intel-android-device-usb-driver


- **Intel® IPP** - A library of highly optimized algorithmic building blocks for media and data applications. It is available under license at http://software.intel.com/en-us/intel-ipp

- **Intel® JTAG Debugger** - A source level debug tool for debugging Android OS kernel software and drivers. The tool is available for both Linux and Windows systems. JTAG Debugger support for BayTrail will be added to Intel® System Studio 2014.

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<tr>
<th>Product</th>
<th>Customer Targets</th>
<th>Product Inclusions</th>
<th>OS Host Support</th>
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<td>Intel C++ Compiler</td>
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<td>Intel® Hardware</td>
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<td>Intel® JTAG</td>
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<td>Intel® Threading</td>
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<td>Intel® System Studio for Android*</td>
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<td>Intel® C++ Compiler for Android</td>
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</table>

Table 6 Intel Tools Features Summary

References

3. Intel IDF 2013 presentations:
   - Building Android® Systems with Intel® Architecture Based Platforms
   - Tablet Solutions in Business: Build on Intel® Technologies for Differentiation
   - Display Technologies for Intel® Graphics
   - Hands-on Lab: Develop, Optimize, Debug, and Tune Applications for Android®
   - Using the Second-Screen API and Intel® Wireless Display from Android® Applications
   - Accelerating Your Software Development for Android® on Intel® Platforms
   - Developing Native Applications on Android and Optimizing for Intel® Architecture
   - Technology Insight: Intel® Platform for Tablets, Code Name Bay Trail-T
   - Technology Insight: Intel Silvermont Microarchitecture
   - Tablets with Android® and Intel® Atom™ Processors