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Android™ on i.MX Applications Processors

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Senior Product Manager
Session Introduction

► Overview of Android and why is it relevant to the consumer industry

► Intermediate level technical details of Android

► Understand the positioning of Freescale i.MX SoCs for Consumer

► High level details of our implementation of Android on i.MX
Agenda

► Android Introduction

► Key features and enhancements

► i.MX Roadmap

► Android on i.MX – Technical details

► Optimizations

► Review and Q&A
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What is Android?

- A free, open source and fully customizable software platform and operating system for mobile devices
- Based on the Linux kernel
- Offers a full software stack: an operating system, middleware, and key applications
- Also contains a rich set of APIs that allows third-party developers to develop great applications
- Developed by Google and later the Open Handset Alliance (OHA)
- Allows writing managed code in the Java language
- Unveiling of the Android platform was announced on 5 November 2007 with the founding of OHA
- Android is under version 2 of the Apache Software License (ASL)
What is Open Handset Alliance (OHA)?

► A group of mobile and technology leaders responsible for the creation and proliferation of Android and an open mobile ecosystem

► Devoted to advancing open standards for mobile devices

► Develop technologies that will significantly lower the cost of developing and distributing mobile devices and services

► Freescale joined OHA in early 2010
Android Platform details

► Android uses Linux for its device drivers, memory management, process management, and networking

► The next level up contains the Android native libraries. They are all written in C/C++ internally, but you’ll be calling them through Java interfaces. In this layer you can find the Surface Manager, 2D and 3D graphics, Media codecs, the SQL database (SQLite), and a native web browser engine (WebKit)

► Dalvik Virtual Machine. Dalvik runs dex files, which are converted at compile time from standard class and jar files
Android – Software Stack on Mobile Device

Apps (Java) – Everyone can create his/her own application based on “Open” Android API

Middleware (Java) – App framework including window/focus management, inter-app communication, event notification, etc

Middleware (C/C++) – system libraries for media, graphic, database, font, web engine, etc

Android “Program” API

Android “Porting” I/F

2.6 based Linux kernel with Android patch. “Open Source” already

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Android Software development Kit and tools

► Android SDK
  • Class Library
  • Developer Tools
    ▪ dx – Dalvik Cross-Assembler
    ▪ aapt – Android Asset Packaging Tool
    ▪ adb – Android Debug Bridge
    ▪ ddms – Dalvik Debug Monitor Service
  • Emulator and System Images
  • Documentation and Sample Code

► Eclipse IDE + ADT (Android Development Tools)
  • Reduces Development and Testing Time
  • Makes User Interface-creation easier
  • Makes Application Description Easier
Past Android releases

1.5 (Cupcake)
On 30 April 2009, the official 1.5 (Cupcake) update for Android was released.

1.6 (Donut)
On 15 September 2009, the 1.6 (Donut) SDK was released.

2.0/2.1 (Eclair)
On 26 October 2009, the 2.0 (Eclair) SDK was released.

On 3 December 2009 the 2.0.1 SDK was released.

On 12 January 2010 the 2.1 SDK was released.
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Some key features of Android

► Connectivity
  • Supports connectivity technologies including GSM/EDGE, CDMA, EV-DO, UMTS, Bluetooth, and Wi-Fi

► Web browser
  • Web browser available in Android is based on the open-source WebKit application framework

► Media
  • Supports the following audio/video/still media formats: H.263, H.264 (in 3GP or MP4 container), MPEG-4 SP, AMR, AMR-WB (in 3GP container), AAC, HE-AAC (in MP4 or 3GP container), MP3, MIDI, OGG Vorbis, WAV, JPEG, PNG, GIF, BMP

► Hardware and graphics
  • Can use video/still cameras, touchscreens, GPS, accelerometers, magnetometers, accelerated 2D bit blits (with hardware orientation, scaling, pixel format conversion) and accelerated 3D graphics

► Android Market place
  • Catalog of applications that can be downloaded and installed to target hardware over-the-air, without the use of a PC

► Multi-touch
  • Has native support for multi-touch which is available in newer handsets such as the Nexus One

► Dev environment
  • Includes a device emulator, tools for debugging, memory and performance profiling, a plugin for the Eclipse IDE
Kernel enhancement

- Binder (Android IPC support)
- PMEM
- ASHMEM
- Logger
- Power
- USB gadget
- Low Memory Killer
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The Fourth Screen: Learning, Reading, Entertainment, Education, Communication and Beyond

Display Centric Connected Devices

- Smartbooks
- Portable Media Players
- eReaders
- Advanced Smartphones
- Infotainment/Telematics
- Factory HMI
- Media Phones
- Mobile Internet Device
- Energy Gateways
- Touch Screen Printers
- Photo Frames

Trends driving need for an intuitive, rich user experience with seamless connectivity. See it and touch it

- Proliferation of tablet centric devices
- Content consumption vs content creation
- Instant on and always connected
- Great user experience – HMI and multimedia

Requirements:
- Optimized performance at lowest power
- Price and performance scalability
- Open OS support with complete solution
- Strong ecosystem
- Tightly integrated graphics and multimedia

Smart processing solutions for the connected world

Enabling the Connected Multimedia Experience
Applications Processors (i.MX) Roadmap

Consumer usage:

High tier smartbook

Smartbook
Smartphone

eReader

i.MX31 family
- ARM1136, 532MHz
- Graphics
- mDDR

i.MX35 family
- ARM1136, 532 MHz
- Graphics
- DDR2

Next gen

i.MX508
- Cortex-A8, 800 MHz
- Graphics
- E INK display Controller
- 512MB LP-DDR2

PMP

i.MX27 family
- ARM926, 400MHz
- Video
- STMP37xx
- ARM926, 266-400MHz
- Integrated PMIC

i.MX25 family
- ARM926, 400MHz
- i.MX233

Next gen

i.MX53 family
- Cortex-A8, 1 GHz
- 1080p video
- 2D/3D graphics
- DDR2/3 800 MHz

i.MX51 family
- Cortex-A8, 800MHz
- Video (720p dec)
- Graphics
- 512MB DDR2

i.MX51 family
- ARM926, 454 MHz
- Integrated PMIC

i.MX31 family
- ARM926, 266-400MHz
- Video
- mDDR

i.MX35 family
- ARM926, 400MHz
- Graphics
- DDR2

<2008

2009

2010

C90 i.MX Platform
C90/C85 STMP
Platform
C65 A8 Platform

Right Edge = Consumer Qualification
Left Edge has no meaning

Example of Consumer usage:

i.MX27 family
- ARM926, 400MHz
- Video
- STMP37xx
- ARM926, 266-400MHz
- Integrated PMIC

i.MX25 family
- ARM926, 400MHz
- Graphics
- 512MB DDR2

Next Gen

i.MX51 family
- Cortex-A8, 800MHz
- Video
- Graphics
- 512MB DDR2
i.MX Value Proposition

► i.MX silicon and software solution that enables world-class smartbook/tablet products with real-world consumer benefits

► Complete hardware and software package provided to enable faster time to market and lower R&D investment

  • BSP’s available for Android and other major smartbook/tablet OS’s
  • Full-featured media framework, including HW-accelerated Flash 10
  • Significant investment in HW-acceleration for Linux® and Android™ UI framework
  • Partners in place to provide UI and application customizations if needed
  • Design collateral up to and including complete form-factor reference design
  • Extensive tablet and smartbook consumer market research and thought leadership
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Readiness
An “integrated” solution (kernel + Android framework + dev/debug environment) instead of a “Android compliable” kernel only. Customer should be able to directly develop applications on this “integrated” solution or easily modify/replace their own drivers based on our reference code. i.e. our BSP needs to be “glued” with Android framework seamlessly.

Performance
Our i.MX + Android integration shows higher performance by careful optimization (e.g. utilizing HW acceleration, SW codec optimization) on current Android base.

Contribution
Freescale is now an OHA member
Participate and actively contribute in the OHA community.
What we did for Android on i.MX - Kernel Porting
What we did for Android on i.MX - Connecting kernel with Android
What we did for Android on i.MX - Tuning for higher performance
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Freescale takes numerous optimization into Android

► Performance optimization for video/audio playback
  • Incorporated audio codecs optimized specific for Cortex™-A8/Neon
  • Incorporated video accelerator to enable 720p playback
  • Incorporated video accelerator to enable D1 camcording
  • Video rendering
    ▪ Rendering video through overlay instead of the SurfaceFlinger (UI)
    ▪ Video overlay is accelerated by hardware
    ▪ Frame buffers are shared between the decoder and renderer so avoid memory copy

► Performance optimization for 3D and UI by using the GPU
  • Incorporated the GPU for 3D processing
  • Hardware Bitblt to combine surfaces into the display buffer

► Functional enhancement for Android OpenCORE
  • Added more formats: AVI, MKV, FLV, ASF and RM
  • Added more codecs: WMV7/8/9, WMA, Ogg Vorbis and AC3 decoders
  • Added MP3 for audio encoding

► Product-quality test
## Video playback performance comparison between un-optimized and optimized Android

<table>
<thead>
<tr>
<th>Container</th>
<th>Video</th>
<th>Audio</th>
<th>Resolution/ Framerate</th>
<th>CPU loading</th>
<th>Frame Dropping Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Original</td>
<td>Optimized</td>
</tr>
<tr>
<td>MP4</td>
<td>MPEG-4</td>
<td>AAC-LC</td>
<td>320x240/30</td>
<td>56.5%</td>
<td>7.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>640x480/30</td>
<td>96.5%</td>
<td>8.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>720x576/30</td>
<td>&gt;97%</td>
<td>9.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1280x720/30</td>
<td>N/A</td>
<td>11%</td>
</tr>
<tr>
<td>H.264</td>
<td></td>
<td></td>
<td>320x240/30</td>
<td>79.6%</td>
<td>7.0%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>640x480/30</td>
<td>N/A</td>
<td>7.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>720x576/30</td>
<td>N/A</td>
<td>8.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1280x720/30</td>
<td>N/A</td>
<td>11.2%</td>
</tr>
</tbody>
</table>

### Notes
- The test is carried out on Freescale Babbage 3.0 board with WVGA output
- N/A means this specification is not supported
- The original Android supports MPEG-4 up to VGA and H.264 up to CIF with acceptable quality
- Freescale version with optimization supports MPEG-4 and H.264 up to 720p without frame dropping
Multimedia – Audio/Video Codec

APPLICATIONS

Audio/Video Apps

APP FRAMEWORK

MediaPlayer/Recorder Class

RUNTIME -> NATIVE

JNI

NATIVE LIBRARIES

IPC binding

MediaPlayer Service (Native) -> Media Library

PV OpenCore Player/Author Engine

PV MedialInput Node

PV SW Codec/Parser

PV MediaOutput Node

OpenMAX IL I/F

FSL OMX Core

FSL Audio Codecs with OMX IL

FSL Video Codecs with OMX IL

LINUX KERNEL

VPU Driver

PV MediaInput Node

PV SW Codec/Parser

FSL OMX Core

FSL Audio Codecs with OMX IL

FSL Video Codecs with OMX IL

VPU Driver
### Matrix of Multimedia Codecs

<table>
<thead>
<tr>
<th>File Extension</th>
<th>Video Decoders</th>
<th>Audio Decoders</th>
</tr>
</thead>
<tbody>
<tr>
<td>.mp3</td>
<td></td>
<td>MPEG-1 Audio Layer I/II/III</td>
</tr>
<tr>
<td>.aac/.adts</td>
<td></td>
<td>AAC LC/PLUS</td>
</tr>
<tr>
<td>.mp4</td>
<td>- MP4V:MPEG-4 SP/ASP except GMC</td>
<td>AAC LC/PLUS</td>
</tr>
<tr>
<td></td>
<td>- H264: H.264 BP/HP</td>
<td>MP3</td>
</tr>
<tr>
<td>.m4a</td>
<td>- MP4V:MPEG-4 SP/ASP except GMC</td>
<td>AAC LC/PLUS</td>
</tr>
<tr>
<td>.3gp</td>
<td>- MP4V:MPEG-4 SP/ASP except GMC</td>
<td>AAC LC/PLUS</td>
</tr>
<tr>
<td></td>
<td>- H264: H.264 BP/HP</td>
<td>AMR-NB</td>
</tr>
<tr>
<td>.mp4</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>- H264: H.264 BP/HP</td>
<td>MP3</td>
</tr>
<tr>
<td>.avi</td>
<td>- MP4V:MPEG-4 SP/ASP except GMC</td>
<td>AAC LC/PLUS</td>
</tr>
<tr>
<td></td>
<td>- Xvid</td>
<td>MP3</td>
</tr>
<tr>
<td></td>
<td>- H264: H.264 BP/HP</td>
<td>Divx4/5/6</td>
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<tr>
<td>.wma</td>
<td></td>
<td>WMA STD, PRO, Lossless</td>
</tr>
<tr>
<td>.wma/.asf</td>
<td>- VC1: VC-1 SP/MP/AP</td>
<td>WMA STD, PRO, Lossless</td>
</tr>
<tr>
<td></td>
<td>- WVC1</td>
<td></td>
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<tr>
<td></td>
<td>- WMV7, 8</td>
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<tr>
<td>.mkv/.mka</td>
<td>- H264: H.264 BP/HP</td>
<td>AAC</td>
</tr>
<tr>
<td></td>
<td>- Xvid</td>
<td>MP3</td>
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<tr>
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<td>WMA STD, PRO, Lossless</td>
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<tr>
<td></td>
<td>- VC1: VC-1 SP/MP/AP</td>
<td>Vorbis</td>
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<td></td>
<td>- MPEG4</td>
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<tr>
<td>.flv</td>
<td>- Sorenson H263</td>
<td>MP3</td>
</tr>
<tr>
<td></td>
<td>- H264: H.264 BP/HP</td>
<td>AAC</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>File Extension</th>
<th>Video Encoders</th>
<th>Audio Encoders</th>
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<tbody>
<tr>
<td>.3gp</td>
<td>H263</td>
<td>AMR-NB</td>
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<tr>
<td>.mp4</td>
<td>H264</td>
<td>MP3</td>
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<tr>
<td>.avi</td>
<td>DivX3</td>
<td>AC3</td>
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<tr>
<td>.ra</td>
<td></td>
<td>RA6, RA9/10 (AAC-LC)</td>
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<tr>
<td>.rm/rmvb</td>
<td>RV8/9/10</td>
<td>RA6 (Up to 2 audio channel), RA9/10 (AAC-LC)</td>
</tr>
<tr>
<td>.mkv/mka</td>
<td>RV8/9/10</td>
<td>AC3, RA6 (Up to 2 audio channel), RA9/10 (AAC-LC)</td>
</tr>
</tbody>
</table>
3DMM gaming

- Samurai
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Open discussion
Key messages

► Freescale Semiconductor enables customers with integrated hardware/software solutions to realize faster time to market. The Android platform provides a compelling and innovative end user experience to support this effort.

► The i.MX5x Applications processor family with Android is a full hardware and software solution that is ideal for high performance, low power and cost effective mobile devices, including smartphones and other smart mobile devices such as smartbooks and eReaders.

► The i.MX51 EVK offers a fully integrated and tested Android platform with optimized codecs and graphics and a development and debug environment. This solution is based on the latest stable Android kernel/release.

► Freescale is a member of the Open Handset Alliance™ - a group of mobile and technology leaders responsible for the creation and proliferation of Android and an open mobile ecosystem.
Learn more on...

http://www.freescale.com/imxandroid
A Freescale supported open web community of developers sharing common interest in transforming i.MX applications processors into practically anything imaginable.

i.MX Community

- Serves all component enablement peripherals including basic to complex software
- i.MX Forums, Groups and Blogs Posts
- News, Photos and Videos
- Training, Events and Promotions

Check it out!
Become a member today and you will be entered to win a i.MX development system of your choice. Drawing will be held on June 30th.