Application Processors for Embedded Applications

July 2013
Agenda

- Trends in embedded
- Cortex®-A series processors in embedded applications
  - Current use cases
  - Future use cases
- Building embedded SoCs using Cortex-A series processors
- Summary
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# Embedded Sub-Segments

<table>
<thead>
<tr>
<th>Automotive/Transportation</th>
<th>Industrial Automation</th>
<th>Medical Electronics</th>
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<tbody>
<tr>
<td>- Multimedia</td>
<td>- Lighting</td>
<td>- Diagnostic Equipment</td>
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<tr>
<td>- Dashboard/Driver information</td>
<td>- HVAC, Refrigeration and Power</td>
<td>- Patient Monitoring</td>
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<tr>
<td>- Body Control</td>
<td>- Security, Fire and Safety</td>
<td>- Imaging and Scanning</td>
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<tr>
<td>- Chassis &amp; Safety systems</td>
<td>- Machine Drives</td>
<td>- Consumer Medical</td>
</tr>
<tr>
<td>- Powertrain</td>
<td>- Controls &amp; Compute/PLC</td>
<td>- Medical Therapy</td>
</tr>
<tr>
<td>- Rail &amp; Other Transport</td>
<td>- Operator Interfaces/HMI</td>
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<thead>
<tr>
<th>Military &amp; Aerospace</th>
<th>Smartcard</th>
<th>Retail Automation</th>
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<tr>
<td>- C4I &amp; EW</td>
<td>- Access Control</td>
<td>- Asset Tracking (RFID, etc.)</td>
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<tr>
<td>- Sonar &amp; Radar</td>
<td>- SIM Cards</td>
<td>- Payment Platforms</td>
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<tr>
<td>- Space Systems</td>
<td>- Payment Cards</td>
<td>- Point of Sale Terminals</td>
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<tr>
<td>- Simulation</td>
<td>- Identity Cards</td>
<td>- Handheld Scanners &amp; Readers</td>
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<tr>
<td>- Avionics</td>
<td>- Secure NFC</td>
<td>- Fixed Terminals</td>
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<td>- Weapons Control</td>
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<tr>
<th>M2M</th>
<th>Smart Energy</th>
<th>Motor Control</th>
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<tr>
<td>- Personal Health</td>
<td>- Smart Grid</td>
<td>- AC Drives</td>
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<tr>
<td>- Sensor Networks</td>
<td>- Smart Meters</td>
<td>- DC Drives</td>
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<tr>
<td>- Public Infrastructure</td>
<td>- Smart Appliances</td>
<td>- Medium Voltage</td>
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<tr>
<td>- Tracking</td>
<td>- Demand Response Gateways</td>
<td>- Servo</td>
</tr>
<tr>
<td>- Transport Management</td>
<td>- Monitoring Displays</td>
<td>- Stepper</td>
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</table>
Consumer Trends Driving Embedded Innovation

- Rich UI
- Fast responsiveness
- Connectivity
- Personalization
- Content On Demand
- Commerce
- Security
- Low Power

CoT (Cost of Technology)
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Use Case: Thermostat (Cortex-M to A)

- Programmable
- LCD Display
- Connected
- Rich display
- Learning
Use Case: Thermostat (Cortex-M to A)

High performance Cortex-A8 microprocessor

- ARMv7-A architecture
- NEON™ multimedia extensions
- Floating Point Unit (FPU)
- Thumb®
- TrustZone®
- Memory Management Unit (MMU)

http://www.ifixit.com/Teardown/Nest+Learning+Thermostat+2nd+Generation+Teardown/13818/1
Use Case: Wearable Computing
Use Case: Wearable Computing

Cortex-A9 dual-core

- Symmetric Multiprocessing (SMP) support
- High efficiency superscalar pipeline
- NEON media processing engine
- Floating point unit (FPU)
- Thumb-2
- TrustZone support

High performance in very small form factors

http://www.catwig.com/google-glass-teardown/
Use Case: ARM Cortex-A in IVI

- Diversity of ARM-based designs
  - IVI Standard driven as well as proprietary
  - Scalability from Low-End to High-End systems
System Scalability

High end Video
Multimedia extension to back seats

Navigation & Infotainment services
GPS
Location based services

Telematics box
Fleet management services

Basic audio profile
Radio, audio, digital media
BT, telephone integration
Smart Devices at the Heart of Our Lives

Bluetooth LE – Personal world
Personalized ultra low power comms
Low latency data connection

LTE – Mobile broadband
Permanently connected
Enables wireless HD streaming

WiGIG – Personal broadband
HD video streaming
Split screen gaming

NFC – Touch to connect
Touch to pay
Touch to share
Enables highly secure localized comms
Personal notifications
Controlling content

Smart metering

Sport & Lifestyle
Gaming & toys
Personal devices
Mobile payments

Healthcare

Security

Consumer goods

Recreation
Internet of Things Nodes

- Sensing and/or Smart Devices
- Connectivity Nodes
- Connectivity Nodes
- Remote Cloud-based Processing

**Cortex-M**

**Cortex-A**

**Processing Power**

Scalable CPU ISA, Standard Boards, Software, and Development Ecosystem

The Architecture for the Digital World
Use Case: From Sensor to Cloud

**Edge Clients**
- **Temp**
- **Prox**
- **control**
- **Sensors**
  - **Camera**
  - **Infrared**

**Thin client**
- Cortex-M

**Thick client**
- Cortex-A

**Gateway**
- Multi-core Cortex-A

**Access Network**
- Device Provisioning and Diagnostics
- Access Network: e.g. 3G/4G, DSL, DOCSIS Whitespace
- Management Platform

**Cloud Services**
- M2M Apps
  - ‘Big Data’ Storage
  - Cloud Hosting

**Network:**
- e.g. Wi-Fi
- 6lowPan
- BT LE
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ARM Application Processors for Embedded

One size does not fit all embedded applications

Application processors

Performance

Energy efficiency

Cortex-A5

Cortex-A7

Cortex-A8

Cortex-A9

Cortex-A53

32bit, ARMv7

64/32bit, ARMv8

Cortex-A12

2014-15 & beyond

High performance embedded applications

Shipping today in embedded SOC platforms

For a range of embedded applications
Cortex-A5: High Volume and Value

- **Power-efficient Performance**
  - Simple in-order 8-stage, single-issue pipeline
  - Improved branch prediction

- **Full feature set of Cortex-A9**
  - NEON, FPU, TrustZone
  - Symmetric Multi-processing (SMP)

- **Highly configurable**
  - Uniprocessor only version available
  - Optional NEON / FPU
  - Optional external L2 cache

Smallest applications processor with full internet capability
Cortex-A7: Most Efficient ARMv7

Power efficient microarchitecture
- In-order 8-stage, partial dual-issue
- Efficient memory system
  - Integrated L2 cache

Full feature set of Cortex-A15
- Hardware enhanced virtualization
- 1 TB physical memory (40bit addressing)
- NEON, FPU, TrustZone
- big.LITTLE companion to Cortex-A15 using AMBA4 ACE

Full feature set of a high end processor in sub 100mW power per core
Cortex-A9: Widely Adopted

- Performance & power optimized multi-core processor
  - Dual-issue, Out-of-order pipeline
  - Scalable SMP – up-to 4 cores
  - Accelerator Coherency Port (ACP)

- Flexible system architecture
  - Available as a single CPU also
  - Configurable cache sizes
  - Optional second AXI interface
  - Optimized L2 cache controller
  - NEON, FPU, TrustZone

Shipping in high performance embedded applications today
Cortex-A12: High Performance Embedded

Natural successor to Cortex-A9 processor

- More performance
- Improved power efficiency

Architecturally compatible with Cortex-A15 and Cortex-A7

- Hardware support for virtualization
- Integrated L2 cache
- NEON, FPU, TrustZone

Suitable for high performance embedded applications - 2014/15
Cortex-A53: Highest Efficiency ARMv8

Power efficient performance
- In-order, 8-stage, full dual-issue pipeline
- ECC and Parity
- Accelerator Coherence Port (ACP)

Complete ARMv8 Support
- 64bit and 32bit
- Crypto and SHA instructions
- Advanced NEON capabilities
- big.LITTLE companion to Cortex-A57 using AMBA4 ACE

Energy efficient ARMv8 processor for wide range of embedded applications
**Embedded SoC Using Cortex-A**

**Energy efficient Cortex-A7:**
- Scalable performance – up-to 4 Cortex-A7 cores
- Sub 100mW power consumption per core
- High end feature set in a small area and power profile

**Interconnect (CoreLink NIC-400):**
- Highly Configurable
- Adds support for AXI 4 & APB 4 interfaces
- Clock gated for power saving
- End-to-end QoS feature

**Dynamic Memory Controller (DMC-400):**
- DDR2/3, LPDDR2 memories
- AMBA 3 AXI & ACE-lite support
- 1 or 2 memory interfaces for optimising address management
- 1, 2 or 4 system interfaces for optimising datapaths
- End to end QoS
Parking Assistance System

Interconnect (CoreLink NIC-400)

Cortex-A53

SCU

L2 Cache

Mali GPU

DRAM

CAN interface

Flexray interface

Flash

Ethernet switch

Ethernet link

Camera unit

Front view

Camera unit

Back view

Camera unit

Right view

Camera unit

Left view

LCD Display

Display subsystem
**Silicon Choice**

- Embedded computing spans diverse applications
  - Peripherals to meet application needs
  - Competition and constant innovation

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<tr>
<th>Silicon Vendor</th>
<th>Family</th>
<th>ARM Processor</th>
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<tr>
<td><strong>TI</strong></td>
<td>Sitara AM3x</td>
<td>Cortex-A8</td>
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<tr>
<td><strong>NVIDIA</strong></td>
<td>OMAP</td>
<td>Cortex-A9/A8</td>
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<tr>
<td></td>
<td>Keystone AMK5x</td>
<td>Cortex-A15</td>
</tr>
<tr>
<td><strong>Nvidia</strong></td>
<td>Tegra</td>
<td>Cortex-A9/Cortex-A15</td>
</tr>
<tr>
<td><strong>ALTERA</strong></td>
<td>Arria V</td>
<td>Cortex-A9</td>
</tr>
<tr>
<td></td>
<td>Cyclone V</td>
<td>Cortex-A9</td>
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<tr>
<td><strong>XILINX</strong></td>
<td>Zync</td>
<td>Cortex-A9</td>
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<tr>
<td><strong>Atmel</strong></td>
<td>SAMA5D3x</td>
<td>Cortex-A5</td>
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<tr>
<td><strong>freescale</strong></td>
<td>Vybrid</td>
<td>Cortex-A5</td>
</tr>
<tr>
<td></td>
<td>i.MX</td>
<td>Cortex-A9</td>
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SoC Software Development Cost

- More functionality being packed at lower nodes
  - Huge increase in software development costs
- ARM has a strong software ecosystem
  - Android heavily optimized for ARMv7-A architecture
  - Open source and commercial Linux distributions available on ARM
- Continued development and growth in ARM s/w ecosystem

Strong and growing ARMv7 S/W ecosystem reduces SoC S/W development costs and TTM significantly
Capitalizing on the Software Trend

- The ARM Connected Community®
- Solution Center for Android™ (SCA)
- Linaro™
  - Collaborative engineering enables easier, quicker development of optimized open source devices
  - www.linaro.org
- Embedded Software Store
  - A marketplace, developed by ARM & Avnet to drive innovation in embedded software enabling complete silicon solutions
  - www.EmbeddedSoftwareStore.com
Summary

- Different embedded sub-segments ready for double digit growth in next few years

- Trends in consumer are driving innovation in embedded

- High end embedded products shipping with ARM application processors today

- One size does not fit all
  - Different ARM application processors for wide range of embedded applications

- ARM’s strong software ecosystem offers lower cost and fast turn around time
Thank You

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