Mobile and Embedded/IoT market
Overview and Trends

June 2014
Ubiquitous Connectivity

- Contactless Payments
- Wearables
- Ultra HD Media Streaming
- Quantified Self
- Global Wireless Broadband
Wearable Momentum – Built on ARM®

80+ devices in development or already in commercial deployment
ARM at the Heart of Your Smartphone

Apps Processor
- Cortex-A5: Mali™-300
- Cortex-A7: Mali-400
- Cortex-A9: Mali-T604
- Cortex-A15: Mali-T628
- Cortex-A17: Mali-T720

Cellular Modem
- Cortex®-R4
- Cortex®-R5
- Cortex®-R7

Bluetooth
- Cortex-M3
- Cortex-M0

WiFi
- Cortex-M4

SIM
- SecurCore® SC300™

GPS
- Cortex-M3
- Cortex-M0

Flash Controller
- Cortex-M3

Power Mgmt
- Cortex-M3
- Cortex-M0

Touchscreen & Sensor Hub
- Cortex-M0
- Cortex-M3
- Cortex-M4

Camera
- Cortex-M3

Sensor Hub
- Cortex-M0+
Consumer Trends Driving Embedded Innovation

- Rich UI
- Fast responsiveness
- Connectivity
- Personalization
- Content On Demand
- Commerce
- Security
- Low Power
Celebrating 50 Billion ARM-Powered Chips

http://www.50billionchips.com
IoT: Making Things Smart, Connected and Interactive

- Shaping business and consumer focused strategies

- Key enablers include:
  - Tiny, low-cost sensors
  - Secure, standardized Internet and web to the tiniest of devices
  - Authentication and trust
  - Universal data model semantics
  - Easy, open web-based development

26 Billion Installed Units by 2020*

Device Categories

*Gartner
ARM Cortex-M: Ultra Low Power, Size, Cheap + Internet Connected → this is how to get to 10s of Billions

Over 2 Billion

ARM Cortex-M devices shipped in 2013 by leading semiconductor companies

Think Powered by Watch Batteries & Energy Harvesting
Strong Embedded Adoption since ARM7

- Cortex-M3 was announced in 2004; First product released in 2006
ARM Cortex-M Processors – proven success

212+ licensees of Cortex-M processors
Over 3,000 Cortex-M based MCU types
Tens of thousands Cortex-M based applications
Requirements always go higher
Price of ARM Microcontrollers

- Comparable price level to 8/16-bit products

- Save cost by using ARM MCUs
  - Competitive microcontroller prices
  - Reducing time to market
  - Better software reusability
  - Better ecosystem
MCU Code Density

- Cortex-M shows smaller code size than 8/16-bit devices

- Best in-class code density,
  - reducing flash size and
  - power consumption

- Reach smallest form factor and cost
  - Sensors
  - Mobile equipment
  - Medical
ARM Cortex Processor family

Cortex-M0
- “8/16-bit” applications
- Lowest cost
- Outstanding Energy efficiency

Cortex-M0+
- “8/16-bit” applications
- Lowest power
- Performance efficiency
- Feature rich connectivity

Cortex-M3
- “16/32-bit” applications
- Accelerated SIMD, FP & SP

Cortex-M4
- “32-bit/DSC” applications
- MCU plus DSP
- WIDELY ADOPTED
- MARKET PROVEN
- HIGH VOLUME

Consistent architecture across all applications
## Cortex-M Performance & Power considerations

### Dynamic power (µW/MHz)

<table>
<thead>
<tr>
<th></th>
<th>90nm (7-track, typical 1.2v, 25C)**</th>
<th>28nm (9-track C35 HVt, typical 0.9v, 25C)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortex-M0</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>Cortex-M0+</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td>Cortex-M3</td>
<td>40</td>
<td>7</td>
</tr>
<tr>
<td>Cortex-M4</td>
<td>45</td>
<td>9</td>
</tr>
</tbody>
</table>

### CoreMark® and Dhrystone (per MHz)

<table>
<thead>
<tr>
<th></th>
<th>Dhrystone (official)</th>
<th>Dhrystone (max opt)</th>
<th>CoreMark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortex-M0</td>
<td>0.84</td>
<td>1.21</td>
<td>2.33</td>
</tr>
<tr>
<td>Cortex-M0+</td>
<td>0.94</td>
<td>1.31</td>
<td>2.42</td>
</tr>
<tr>
<td>Cortex-M3</td>
<td>1.25</td>
<td>1.89</td>
<td>3.32</td>
</tr>
<tr>
<td>Cortex-M4</td>
<td>1.25</td>
<td>1.95</td>
<td>3.40</td>
</tr>
</tbody>
</table>

* Feature rich configuration

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**90nm:**
- 7-track, typical 1.2v, 25°C

**28nm:**
- 9-track C35 HVt, typical 0.9v, 25°C

**Feature rich configuration**

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* CoreMark data from ARM website and CoreMark.org website
## Ready to Connect the IoT

**ARM Cortex-M processors enables the leading low power RF SoCs**

<table>
<thead>
<tr>
<th>Company</th>
<th>Product Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcom</td>
<td>BCM20736 Bluetooth LE + wireless charging ARM Cortex-M3 Processor</td>
</tr>
<tr>
<td>Sierra Wireless</td>
<td>AirPrime WP6 2G EDGE system-on-chip ARM Cortex-M0 Processor</td>
</tr>
<tr>
<td>GainSpan</td>
<td>GS2000 WiFi &amp; ZigBee IP (6LoWPAN) 2x ARM Cortex-M3 Processors</td>
</tr>
<tr>
<td>Dialog Semiconductor</td>
<td>DA14580 Bluetooth LE ARM Cortex-M0 Processor</td>
</tr>
<tr>
<td>Linear Semiconductor</td>
<td>LTC5800-IMP 2.4GHz (802.15.4 / 6LoWPAN) ARM Cortex-M3 Processor</td>
</tr>
<tr>
<td>Nordic Semi</td>
<td>nRF51822 Bluetooth LE ARM Cortex-M0 Processor</td>
</tr>
<tr>
<td>Freescale</td>
<td>KW01 / KW20 Sub-1 GHz / Zigbee ARM Cortex-M0+/M4 Processor</td>
</tr>
<tr>
<td>TI</td>
<td>EM35x CC2538 ZigBee system-on-chip ARM Cortex-M3 Processor</td>
</tr>
</tbody>
</table>
ECB is another key carrier board solution for IoT deployment.
## “Buy vs. Make” Embedded Computing Boards

<table>
<thead>
<tr>
<th>Customer Challenges</th>
<th>Full Custom (Make)</th>
<th>Standard Board (Buy)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time-to-Market</strong></td>
<td>• Longer time required to do hardware development</td>
<td>• Shorter period as hardware and BSP is ready immediately allowing faster reaction to market needs.</td>
</tr>
<tr>
<td><strong>BOM Costs</strong></td>
<td>• Lowest</td>
<td>• Potentially lower as R&amp;D cost can be amortized over a larger customer base per board</td>
</tr>
<tr>
<td><strong>Lowering development costs as system complexity increases</strong></td>
<td>• Dedicated resources need to keep up with each technologies in the system translates into more costs for human capital</td>
<td>• Complex boards designed by module vendors reduces risky, complexity and costly for OEM</td>
</tr>
<tr>
<td><strong>Increase value through internal IP development</strong></td>
<td>• Some IP may not be differentiating or valued by the customer</td>
<td>• Limits the OEM investments and allows critical resources to be applied to IP that creates value.</td>
</tr>
<tr>
<td><strong>Long product life cycles</strong></td>
<td>• OEM takes responsibility for all elements of design</td>
<td>• OEM off loads some of the responsibility to system board maker</td>
</tr>
</tbody>
</table>
ARM in Embedded Computing Board (not limited)
ARM for ECB market is about

- **Energy Efficiency**
  - Performance per watt; Small form factor
  - Simpler power electronics to reduce BOM and weight
  - Save cost for heat sink, transport and installation
  - Broader application space such as battery powered

- **Increased Customer Choice**
  - Embedded computing spans diverse applications
  - Peripherals to meet application needs
  - Competition and constant innovation

More are Coming!!!
Platform Era of Embedded Development

1990s

Assembler

2000s

C

2010s

Platform
Make the creation of billions of connected devices possible

- **mbed™ will enable IoT device creation on a massive scale**
  - An open source platform for Cortex-M Microcontrollers
  - Opening up IoT to a vast new audience of professional developers

- **Consolidating fundamental embedded building blocks**
  - Microcontrollers, Radios, Sensors, Software stacks
  - Bluetooth, 802.15.4/6LoWPAN, WiFi, Cellular
  - Embedded agents and APIs for cloud services

- **With the right tools and ecosystem**
ARM mbed for connected device creation

See mbed.org/platforms

DipCortex M3
- Cortex-M3, 72MHz
- 64KB Flash, 12KB RAM

BlueBoard-LPC11U34
- Cortex-M4, 48MHz
- 32KB Flash, 8KB RAM

WIFI DipCortex
- Cortex-M3, 90MHz
- 64KB Flash, 12KB RAM

Seeeduino-Arduvino
- Cortex-A4, 300MHz
- 512KB Flash, 512KB RAM

ST Nucleo L152RE
- Cortex-M0, 36MHz
- 512KB Flash, 64KB SPIAM

ST Nucleo F401RE
- Cortex-M4, 98MHz
- 512KB Flash, 64KB SPIAM

Seeeduino-Arduvino
- Cortex-M0, 180MHz
- 32KB Flash, 8KB RAM

LPC11F428
- Cortex-M0, 80MHz
- 32KB Flash, 4KB RAM

u-blox C927
- Cortex-M3, 96MHz
- 512KB Flash, 128KB RAM
- Onboard cellular module

ST Nucleo F030RE
- Cortex-M0, 48MHz
- 64KB Flash, 8KB SPIAM

FRDM-K64F
- Cortex-M4, 120MHz
- 144KB Flash, 256KB RAM
- Ethernet, SD Filesystem

Nordic nRF51822
- Bluetooth v4.1
- Cortex-M3, 16MHz
- 128KB Flash, 16KB RAM
ARM IoT Architecture – ARM Offering

BIG DATA

Little Data

End-to-End Security, Web, Data Objects & Management

Security

Communication

Discovery

Data Storage & Analytics

Management

Applications
Building the Embedded Web
Sensinode: Building the Embedded Web

Vision

The Internet of Things (IoT) is the next evolution of the Internet where devices of all types and capabilities are connected through Internet Protocol and Web Services

Mission

Create value for customers and partners through innovative software solutions that enable the Internet of Things by optimizing the way businesses and consumers collect, manage and leverage information

Heritage

- Leading supplier of end-to-end SW solutions for M2M applications since 2005
- Led the creation of 6LoWPAN and CoAP – essential technologies for the IoT
- Key player and contributor to all major IoT-relevant standards bodies
- Acquired by ARM in August 2013
Protocols for constrained IOT devices

**IPv6** → **6LoWPAN**
- Header compression on sensor networks

**TCP** → **UDP**
- No guarantee of packet delivery or order

**HTTP** → **CoAP**
- HTTP-like (REST) semantics for constrained devices

**TLS** → **DTLS**
- TLS over UDP – stateless – one packet at a time

**Application**
1000s of bytes

**Web Object**

**HTTP**

**TLS** (TCP)

**IPv6**

**IOT Backhaul**
100s of bytes

**Binary Web Object**

**CoAP**

**DTLS** (UDP)

**IPv6**

**Proxy**

**IOT Sensor Network**
10s of bytes

**Binary Web Object**

**CoAP**

**DTLS** (UDP)

**6LoWPAN**
- **Web Application SDK**
  Reference Applications for rapid development of customer application that controls/monitors the M2M nodes.
  - Lighting, Connected Home, Asset Management
  - NodeView Network Management

- **NanoService Platform**
  IoT application and data management platform, may be deployed in private or public server infrastructure.
  - NanoService Clients (C/C++, Java ME, Java SE)
  - NanoService Edge

- **NanoMesh**
  Leading 6LoWPAN protocol stack for low-power RF and power line networks.
NanoService™ – An End-to-End Solution
Illustrative WSN and Cellular Deployments

Smart City Applications

Web Applications

NodeView

NanoService Platform

IPv6, TLS, HTTP, JSON

IPv6, DTLS, CoAP, Binary

IPv6, DTLS, CoAP, Binary

6LoWPAN, DTLS, CoAP, Binary

Smart City Applications

Asset Tracking Applications

Telematics

NanoService Client

NanoMesh

NanoService Edge

NanoMesh

NanoService Client

NanoService Client

NanoService Client
Business Model Enables Expanding Experience

ARM Ecosystem Enables Global Innovation

- Expanding connectivity
- Expanding user experiences
- Expanding global reach
- Expanding device choice
- Expanding form factors
- Expanding markets
Thank You

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