ARM® Processors and the Internet of Things

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Internet of Things is a very Diverse Market

- Smart energy
- Power management
- Servers, Industrial Appliances

- Human interface
- Location aware
- MEMS sensors

- Smart homes
- Security, Safety
- Automotive
- Electric vehicles

Sensing, processing, controlling, automating, communicating, connecting
IoT - Wide Range of Technical Requirements

Wireless

Sensors
• Ultra Low power
• Small silicon area
• Low cost
• High code density
• Low Interrupts processing overhead

Sensor Hubs
• Low power
• Small silicon area
• High performance
• High code density
• Interrupts processing capability
• Real Time

Wearables
• Low power
• Low to Mid-range performance
• Security
• Bare metal to range of OS
• Multi-media

Communications
• Low power
• High performance
• High code density
• Interrupts processing capability
• Real Time

Smart phones
• High performance
• Low power
• Full feature OS
• Full feature Multi-media
• Security

Servers
• Excellent performance
• Energy Efficient
• Full feature OS
• Security
• Scalability
So how does ARM Cortex® Processors Map into Different Applications?
The ARM Processor Family

- Many cores are developed over the years

System capability & performance

Application Processors  
(with MMU, support Linux, MS mobile OS)

Real Time Processors

Microcontrollers and deeply embedded

Classic ARM Processors

ARM Cortex Processors

ARM Cortex Processors

Classic ARM Processors

ARM Cortex Processors
### Wireless

- **Ultra low power**
  - Low gate count
  - High code density
  - Simple system designs
  - Sleep modes support

- **Deterministic behavior**
  - Flexible interrupt management by NVIC
  - Low interrupt latency

- **Scalable instruction set**
  - Simple ISA – Cortex®-M0 / Cortex-M0+
  - Powerful ISA – Cortex-M3 / Cortex-M4

![Diagram of ARM Cortex®-M0, M0+, M3, M4 processors](image)

<table>
<thead>
<tr>
<th>Silicon Labs EM35x</th>
<th>ZigBee system-on-chip</th>
<th>ARM Cortex-M3 Processor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcom BCM20736</td>
<td>Bluetooth LE + wireless charging</td>
<td>ARM Cortex-M3 Processor</td>
</tr>
<tr>
<td>GainSpan GS2000 WiFi &amp; ZigBee IP</td>
<td>6LoWPAN</td>
<td>2x ARM Cortex-M3 Processors</td>
</tr>
<tr>
<td>Sierra Wireless AirPrime WP6</td>
<td>2G EDGE system-on-chip</td>
<td>ARM Cortex-M0 Processor</td>
</tr>
<tr>
<td>Dialog Semiconductor DA14580</td>
<td>Bluetooth LE</td>
<td>ARM Cortex-M0 Processor</td>
</tr>
<tr>
<td>Linear LTC5800-IMP</td>
<td>2.4GHz (802.15.4 / 6LoWPAN)</td>
<td>ARM Cortex-M3 Processor</td>
</tr>
<tr>
<td>Freescale KW01 / KW20</td>
<td>Sub-1 GHz / Zigbee</td>
<td>ARM Cortex-M0+/M4 Processor</td>
</tr>
<tr>
<td>Nordic Semi nRF51822</td>
<td>Bluetooth LE</td>
<td>ARM Cortex-M0 Processor</td>
</tr>
<tr>
<td>TI EM35x CC2538</td>
<td>ZigBee system-on-chip</td>
<td>ARM Cortex-M3 Processor</td>
</tr>
</tbody>
</table>
Sensors / MEMS

- Ultra low power
  - Cutting edge low power & sleep modes (e.g. SRPG)
  - High code density
  - Simple system designs

- Mixed signals
  - Low gate count for analogue processes

- Low cost
**Microcontrollers/Microprocessors**

- Wide range of requirements based on applications
  - Low power, sleep modes
  - High performance
  - Code density
  - Interrupt processing
  - Real Time / RTOS
  - Linux

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- **Freescale SCKL16Z128V** (Cortex-M0+)
- **Ember EM357** integrated ZigBee/802.15.4 SoC (Cortex-M3)
- **Texas Instruments AM3703CUS** Sitara ARM Cortex-A8 microprocessor

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http://www.ifixit.com/Teardown/Nest+Protect+Teardown/20057
Sensor Hubs / Sensor Fusions

- Low Power
  - Low gate count
  - High code density

- Real Time Performance
  - Data processing
  - Interrupt processing

- Deterministic Behaviour
  - Flexible interrupt management by NVIC
  - Low interrupt latency
# Wearable ➔ Diverse Requirements

<table>
<thead>
<tr>
<th></th>
<th>Entry Level</th>
<th>Mid Range</th>
<th>High End</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS</td>
<td>Baremetal / RTOS / Proprietary</td>
<td>Linux / Android / Proprietary</td>
<td>Linux / Android / Proprietary</td>
</tr>
<tr>
<td>GUI</td>
<td>LEDs / small LCD (120 x 120)</td>
<td>LCD (e.g. 220 x 220)</td>
<td>LCD / Glasses</td>
</tr>
<tr>
<td>Processor</td>
<td>Ultra low power processor without MMU (e.g. Cortex®-M3)</td>
<td>Low power Application processor with MMU (e.g. Cortex-A5) + Ultra low power processor (e.g. Cortex-M0+) for background I/O tasks</td>
<td>Energy Efficient Application processor with MMU (e.g. Cortex-A12) + Ultra low power processor (e.g. Cortex-M0+) for background I/O tasks</td>
</tr>
<tr>
<td>GPU requirement</td>
<td>-</td>
<td>Maybe (Mali™-4xx)</td>
<td>Yes (Mali-4xx / Mali-6xx )</td>
</tr>
<tr>
<td>Video Engine</td>
<td>-</td>
<td>-</td>
<td>Maybe (Mali-500)</td>
</tr>
<tr>
<td>Audio</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Connectivity</td>
<td>Bluetooth / USB</td>
<td>Bluetooth / WiFi / USB</td>
<td>Bluetooth / WiFi / USB / mobile</td>
</tr>
<tr>
<td>GPS</td>
<td>-</td>
<td>-</td>
<td>Maybe</td>
</tr>
</tbody>
</table>
Wearables – Entry Level Range

- Low power (battery powered)
  - Low gate count
  - High code density
  - Sleep modes support

- Connectivity
  - Protocol stack
  - Interrupt processing
  - Data processing

- Low cost
Wearables – Mid Range to High End

- Virtual Memory /MMU
  - Linux / Android

- High performance
  - Floating point
  - NEON™ Adv SIMD
  - SMP multicore
  - AXI/ACP/Cache
  - Graphics

- Security
  - TrustZone
Smart Phones to Super Phones

**Performance**
- Multi-core
- Superscalar
- NEON™ Adv SIMD
- FPU
- Graphics

**Efficiency**
- big.LITTLE™

**Security**
- TrustZone®
Communication, Infrastructure

- High performance
  - FPU
  - Cache memory

- Deterministic
  - Low interrupt latency
  - Low Latency Peripheral Port
  - TCM

- Reliability
  - MPU
  - ECC / Parity
Servers / Enterprise

- **Performance**
  - 64-bit / 32-bit
  - Multi-core
  - Superscalar
  - NEON Adv SIMD
  - FPU
  - Cache, SCP
  - Crypto
  - GPGPU/Open-CL

- **Efficiency**
  - big.LITTLE™

- **Security**
  - TrustZone®

(Mali-T6xx/T7xx support Open-CL full profile 1.1)
There are Much More in a System…

- System IP (CoreLink™)
  - AHB / AXI / ACE bus interconnect
  - DMA controller
  - L2 cache controller
  - Memory Controller (e.g. DDR)
  - AMBA® Designer
- Mali GPU / Video Engine / Display Processor
  - Advanced graphics UI
  - GPGPU/Open-CL
- Additional debug and trace IP
  - CoreSight™ SoC
- Physical IP
  - Cell libraries, memories, I/O
Summary

- IoT is a hugely diverse market
  - One size doesn’t fit all
  - ARM processors powering most of the wearable devices today
  - ARM technologies in many IoT products

- ARM is in the leading market position
  - Wide range of processors for different IoT segments
  - Additional system IP solutions (e.g. interconnect, memory controller)
  - Close collaboration with various parties
  - Largest ecosystem in the industry
  - Strongest product roadmap

www.50billionchips.com
Thank You

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