ARM Microprocessor Basics

Introduction to ARM Processor
About EmbeddedCraft

- Embedded System Information Portal, regularly publishes
  - Tutorials / Articles
  - Presentations
  - Example Program
  - Latest News

- Follow us on
  - Twitter: https://twitter.com/embeddedcraft
  - YouTube: http://www.youtube.com/embeddedcraft

http://embeddedcraft.org/
Agenda

- ARM introduction
- ARM Based Products
- ARM Features
- ARM Processor Family
- ARM Nomenclature
- ARM Processor Architecture (ARM core)
- ARM Development Tools
Introduction

- **ARM: Advance RISC Machine**
- ARM was established as a joint venture between Acorn, Apple and VLSI in November 1990.
- ARM is the industry's leading provider of 16/32-bit embedded RISC microprocessor solutions.
- The company licenses its high-performance, low-cost, power-efficient RISC processors, peripherals, and system-chip designs to leading international electronics companies.
- ARM provides comprehensive support required in developing a complete system.

http://embeddedcraft.org/
Role of ARM Co.

- ARM Holdings is a technology company headquartered in Cambridge, England, UK.

- The company is best known for its processors, although it also designs, licenses and sells software development tools under the RealView and KEIL brands, systems and platforms, system-on-a-chip infrastructure and software.

- ARM do not make ICs !!!

- ARM grant license of core to different silicon vendors like ATMEL, NXP, Cirrus logic etc
  - These companies make ICs
  - Examples are: LPC2148 from NXP, AT91RM9200 from ATMEL
Where ARM processors are used

- ARM processors can be used in any domain.
- Mainly ARM processors are used in Handheld devices, Robotics, Automation, Consumer Electronics.
- But ARM processors are available for almost every domain.
ARM Based Products

Apple iPhone
ARM11

Motorola Z8 Smart Phone
ARM11

http://embeddedcraft.org/
ARM Based Products

Blackberry
ARM11

Nokia E90 Communicator
ARM11

http://embeddedcraft.org/
ARM Based Products: Inside the processors

- NVIDIA
- SAMSUNG
- ST microelectronics

- graphics cards
- SAMSUNG processor
- ST microelectronics processor

- Texas Instruments
- OMAP and DaVinci processor

http://embeddedcraft.org/
Network Storage Link for USB 2.0 Disk Drives Network attached storage Linksys (CISCO)
ARM Based Products

GP32 – Game console
ARM9

HP H49 Graphics Calculator
ARM9TDMI
ARM Based Products

iPOD
ARM7TDMI

Juice Box
Low cost Multimedia player ARM7TDMI

http://embeddedcraft.org/
ARM Based Products

Lego Mindstrome Robot
ARM7

Paison Series game consoles
ARM7TDMI

http://en.wikipedia.org/wiki/ARM_architecture
ARM Features 1/2

- ARM are RISC (Reduced Instruction Set Computation) processor
  ARM is not 100% RISC, some amendment to meet the requirement of Embedded System

- Large Register file R0 to R16 (against RISC)

- Load and Store architecture
  data processing is only in register contents

- Uniform and fixed length instructions

- 32 bit processor

- Good speed and power consumption ratio

- High code density

- Mostly single-cycle execution

- Speed 1Mhz to 1.25Ghz
ARM Features 2/2

- **ARM** support JAVA jezelle DBX (Direct Byte code execution)
- DSP Enhanced Instructions
- Support for TrustZone technology additional security core
- Conditional execution of all instructions *(against RISC)*
- 32 bit barrel shifter *(against RISC)*
- In build circuit for debugging

http://embeddedcraft.org/
ARM Processor Family

ARM7TDMI    << Entry Point
Strong ARM
ARM9
ARM9TDMI
ARM9E
ARM10E
ARM11
Cortex
XScale

http://embeddedcraft.org/
ARM Nomenclature

ARMxyzTDMIEJFS

– x: series
– y: MMU
– z: cache
– T: Thumb
– D: debugger
– M: Multiplier
– I: Embedded ICE Macrocel
– E: Enhanced Instructions
– J: Java acceleration by Jazelle
– F: Vector Floating-point
– S: Synthesizable Version
Description (1/2)

- **M - Multiplier**
  ARM processors has hardware multiplier unit doing multiplication

- **I - Embedded ICE Macrocel**
  - This is the hardware circuit which is used to generate trace information.
  - This feature is used in advance debugging and very useful in bug fixing.

- **E – Enhanced Instruction Set**
  - Enhanced instruction set, may be for DSP

- **J – Java acceleration by Jazelle**
  - Hardware circuit which is used to run JAVE byte code

- **F – Vector Floating-point**
  - This is the hardwired implementation of floating operations

http://embeddedcraft.org/
S - Synthesizable Version

- It means ARM architecture can be modified. Because it will come in terms of soft processor core.
Examples

- **ARM7TDMI**
  - This is ARM7 family processor, which has T=thumb instruction set, D = Debug unit, M= MMU, I = trace circuit is inside the core (Embedded Trace Macrocel)
  - This is basic core and all core have TDMI.

- **ARM946E-S**
  - ARM9xx core
  - Enhanced instruction set for DSP
  - Synthesizable
ARM Processor

http://embeddedcraft.org/
Classic processors (ARM7, ARM9, ARM11) and Embedded Cortex processor are specially designed for Embedded Application.
<table>
<thead>
<tr>
<th>ARM CORE</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARM v1 (obsolete)</td>
<td>26 bit instructions, no multiply or coprocessor</td>
</tr>
<tr>
<td>ARM v2 (obsolete)</td>
<td>32 bit result, added co processor</td>
</tr>
<tr>
<td>ARM v3 (obsolete)</td>
<td>32 bit instructions</td>
</tr>
<tr>
<td>ARM v4</td>
<td>Add signed instructions, signed load and store instructions</td>
</tr>
<tr>
<td>ARM v4T</td>
<td>Thumb mode is added</td>
</tr>
<tr>
<td>ARM v5TEJ</td>
<td>Add Support for DSP algo and Java byte code engine (Jazelle)</td>
</tr>
<tr>
<td>ARM v6</td>
<td>Support for SIMD by adding media instructions, Thumb2 ISA. Enhanced support for virtualization by adding TrustZone technology. This make this core ideal for audio/video application</td>
</tr>
</tbody>
</table>
## ARM Processor Architecture (ARM core) 2/2

<table>
<thead>
<tr>
<th>ARM CORE</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARMv6M</td>
<td>Targeted for low cost high performance device. Used in Cortex-M0 and Cortex-M2 series processors</td>
</tr>
<tr>
<td>ARM v7</td>
<td>All cortex processor (except Cortex-M) have ARMv7 core. NEON technology support (Increase media processing throughput 4 times), Optimized Thumb2 core. Enhanced floating operations for 3D graphics. ARMv7 has three profile</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cortex-A</th>
<th>Cortex-R</th>
<th>Cortex-M</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMU and optional support for NEON</td>
<td>Realtime profile implementing a protected memory system architecture based on an MPU (Memory Protection Unit)</td>
<td>Designed for fast interrupt processing and ideal for cost-sensitive devices requiring highly deterministic behaviour and minimal gate count.</td>
</tr>
</tbody>
</table>

http://embeddedcraft.org/
ARM Processor Architecture (ARM core)

Classic ARM Processors
- ARM926
- ARM968
- ARM946
- ARM7TDMI

ARMv4T

ARMv5TJ

Application Cortex Processors
- ARM11MP
- ARM176JZ
- ARM1136J
- ARM1156T2

ARMv6

ARMv7A/R

Embedded Cortex Processors
- Cortex-A9
- Cortex-A8
- Cortex-A5
- Cortex-R4

SecurCore 300

Cortex-M3

Cortex-M0

SecurCore 100

Cortex-M1

ARMv7M

ARMv6M

http://embeddedcraft.org/
ARM in a nutshell 1/2

- ARM processor are widely used Embedded Systems
- ARM has good support of RTOS like Linux, QNX, VxWorks, FreeRTOS etc.
- ARM processor are best known for their low power consumptions and high end processing
- ARM7TDMI is their most successful core
  - 1 Billion devices shipping every quarter
  - Over 90 per second
  - In excess of 500 licenses

http://embeddedcraft.org/
ARM in a nutshell 2/2

- ARM has proprietary and open source development tools
- Proprietary tools
  - Windriver workbench
  - Codesourcery
  - Green Hills
  - KEIL
  - Realview
  - IAR Workbench
- Free Open Source tools
  - GNUARM
  - Yagarto

http://embeddedcraft.org/
From where to start…

- **LPC214x**

- **Reasons**…
  - ARM7TDMI Family
  - Best for entry point feature wise
  - Free development toolchain is available (from open source community and software vendors)

- Development Boards are easily available in market.

- Support for RTOS also.
  - uClinux, FreeRTOS etc
Embedded System Training Programs

ARM
8051
PIC18
Embedded Linux

Imbuent Consultancy & Services
Ludhiana - India

http://www.imbuent.com/
Embedded ARM Development Tools

- ARM Development Tools include
  - IDE
  - Compiler Suite
  - Debugger
  - Simulator
  - JTAG Debugging Probe (Hardware)
  - Development Board (Hardware)

- Both Open Source and Proprietary tools are available in market

http://embeddedcraft.org/
Open Source | Freeware Tools

❖ **IDE**
  - Eclipse IDE (http://eclipse.org/)

❖ **Compiler Suite**
  - GCC Compiler for ARM (http://www.gnuarm.com/)
    (http://www.yagarto.de/)

❖ **Debugger**
  - GNU Debugger (http://www.gnu.org/software/gdb/)

❖ **Simulator**
  - Insight Debugger (http://sourceware.org/insight/)
Proprietary Tools (1)

- **IAR Workbench for ARM** ([http://www.iar.com/](http://www.iar.com/))
  - Complete toolchain including IDE, Compiler, Debugger, Simulator
  - Evaluation / Kickstart version are available for free download
  - IAR also provide IAR PowerPac RTOS for ARM
  - IAR Workbench Tutorial
    - [http://embeddedcraft.org/iar_arm.html#top](http://embeddedcraft.org/iar_arm.html#top)
Proprietary Tools (2)

- **Keil for ARM**  (http://www.keil.com/arm/)
  - Complete toolchain include uvision IDE, Compiler(armcc), Debugger and Simulator
  - KEIL also provide RTX RTOS for ARM
  - Evaluation version is also available for download
Proprietary Tools (3)

- **Sourcery G++** ([http://www.codesourcery.com/sgpp](http://www.codesourcery.com/sgpp))
  - This is a professional toolchain based on GNU tools and Eclipse IDE
  - Complete toolchain include Eclipse IDE, Compiler Debugger and Simulator from GNU tools
  - Sourcery G++ Lite Edition is a freely available for download
Sourcery G++ (http://www.codesourcery.com/sgpp)

- This is a professional toolchain based on GNU tools and Eclipse IDE
- Complete toolchain include Eclipse IDE, Compiler Debugger and Simulator from GNU tools
- Sourcery G++ Lite Edition is a freely available for download
Proprietary Tools (4)

• Other tools are following

  • Green hills Tools for ARM
    http://www.ghs.com/
  • Windriver
    http://www.windriver.com/
  • Embest IDE for ARM
    http://www.armkits.com
  • CrossWorks for ARM
    http://www.rowley.co.uk/
JTAG Debugging Probe (1)

- **Olimex** ([http://www.segger.com/cms/jlink.html](http://www.segger.com/cms/jlink.html))
  - This is USB Powered JTAG In circuit emulator
  - This can be used with various tools like IAR, KEIL, Sourcery++ etc
  - Generally ARM JTAG Debugger is a 20 Pin Interface
JTAG Debugging Probe (2)

- Olimex (http://www.olimex.com)
  - These are cost effective JTAG Emulator
  - This can be used with various tools like IAR, KEIL, Sourcery++ etc
RTOS for ARM | Proprietary

- **Vxworks** from Windriver  (http://www.windriver.com/)
- **Threadx** from Express Logic  (http://www.rtos.com/)
- **μC/OS II** from Micrium  (http://micrium.com)
- **Montavista Linux** from Montavista (http://www.mvista.com)
- **QNX** from QNX software system  (http://www.qnx.com/)
RTOS for ARM | Free and Open Source

- Linux (https://www.rtai.org/)
- uClinux (http://www.uclinux.org/)
- Ecos (http://ecos.sourceforge.net/)
- CooCox (http://www.coocox.org)
- freeRTOS (http://www.freertos.org/)
List of ARM Tutorials @ EmbeddedCraft

- **IAR Tutorial**
  - Embedded ARM Development by IAR workbench
  - [http://embeddedcraft.org/iar_arm.html#top](http://embeddedcraft.org/iar_arm.html#top)

- **Eclipse based tools for ARM**
  - Free development toolchain for arm processor - debugging in eclipse ide
    - [http://embeddedcraft.org/freearmtools3.html#top](http://embeddedcraft.org/freearmtools3.html#top)

- **ARM Page @EmbeddedCraft**
  - [http://embeddedcraft.org/arm.html#top](http://embeddedcraft.org/arm.html#top)
Reference

- ARM website
  http://www.arm.com

- GNUARM
  - http://www.gnuarm.com/

- Wikipedia

- Embeddedcraft
  - http://www.embeddedcraft.org/arm.html
About EmbeddedCraft

- Embedded System Information Portal, regularly publishes
  - Tutorials / Articles
  - Presentations
  - Example Program
  - Latest News

- Follow us on
  - Twitter [https://twitter.com/embeddedcraft](https://twitter.com/embeddedcraft)
  - YouTube [http://www.youtube.com/embeddedcraft](http://www.youtube.com/embeddedcraft)
Thanks

EmbeddedCraft is the information portal for everyone. This site is useful for those who are working in embedded system domain or start new career in this field.

We try to give informative articles from various fields of the embedded technologies.

Disclaimer

All logos used in this website belongs to their respective owners, we have used them here only for information purpose only

http://www.embeddedcraft.org/