EmbeddedCraft
crafting of intelligent systems

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

Agenda

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

Introduction

- ARM: **A**dvance **R**ISC **M**achine

ARM

- ARM was established as a joint venture between Acorn, Apple and VLSI 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

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

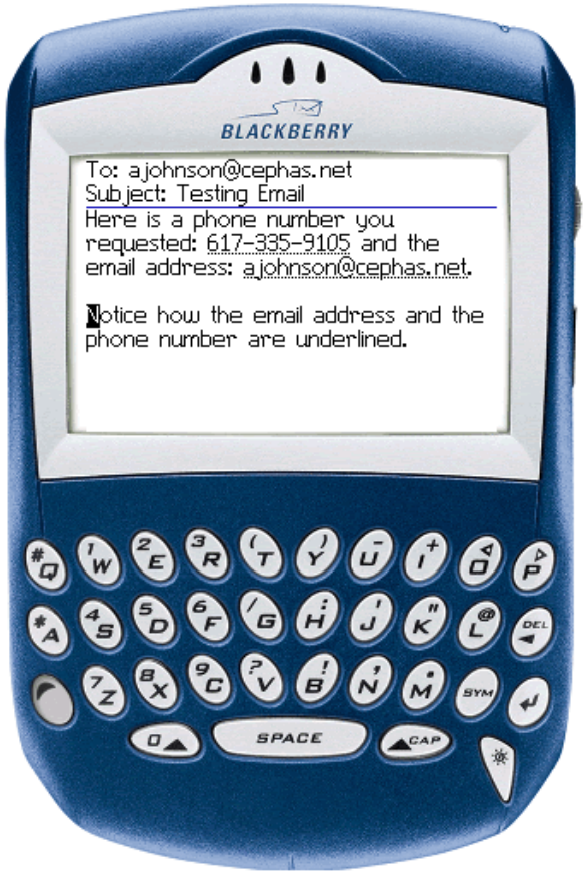
- ARM processors can be used in any domain
- Mainly ARM processors are used in Handheld devices, Robotics, Automation, Consumer Electronics.
- But ARM processors are available for almost every domain.

ARM Based Products

Apple iPhone
ARM11

Motorola Z8 Smart phone
ARM11

ARM Based Products



Blackberry
ARM11

Nokia E90 Communicator
ARM11

ARM Based Products: Inside the processors

graphics cards

SAMSUNG processor

ST microelectronics processor

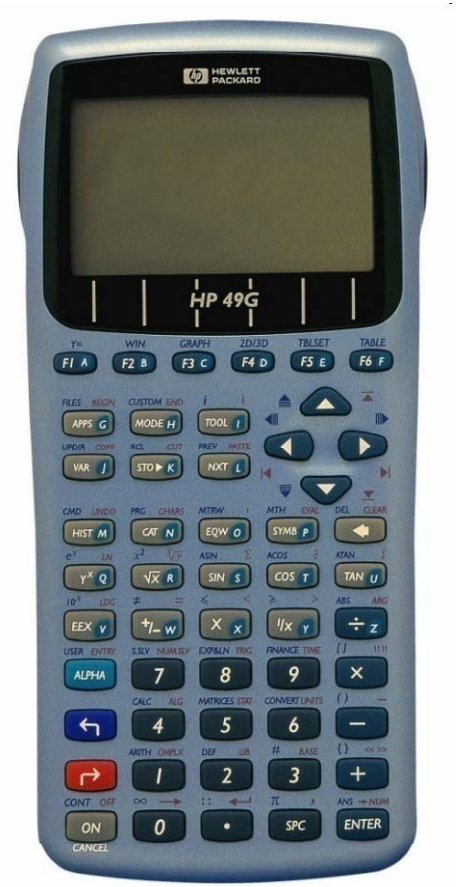
OMAP and DaVinci processor

ARM Based Products

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

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 meets 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

ARM Processor Family

ARM7TDMI << Entry Point

Strong ARM

ARM9

ARM9TDMI

ARM9E

ARM10E

ARM11

Cortex

XScale

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

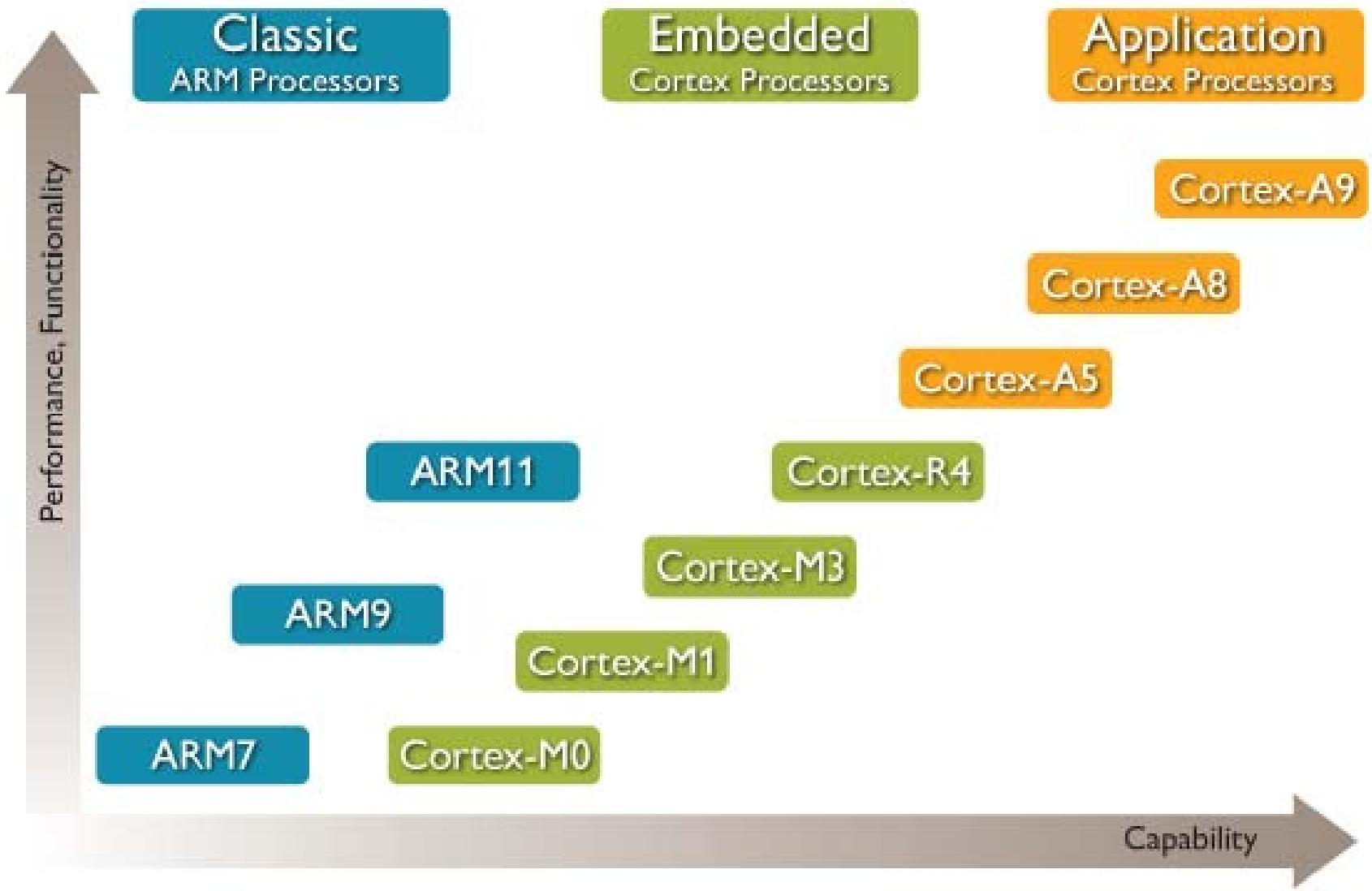
Description (2/2)

- **S - Synthesizable Version**
  - It means ARM architecture can be modified. Because it will comes in terms of soft processor core

Examples

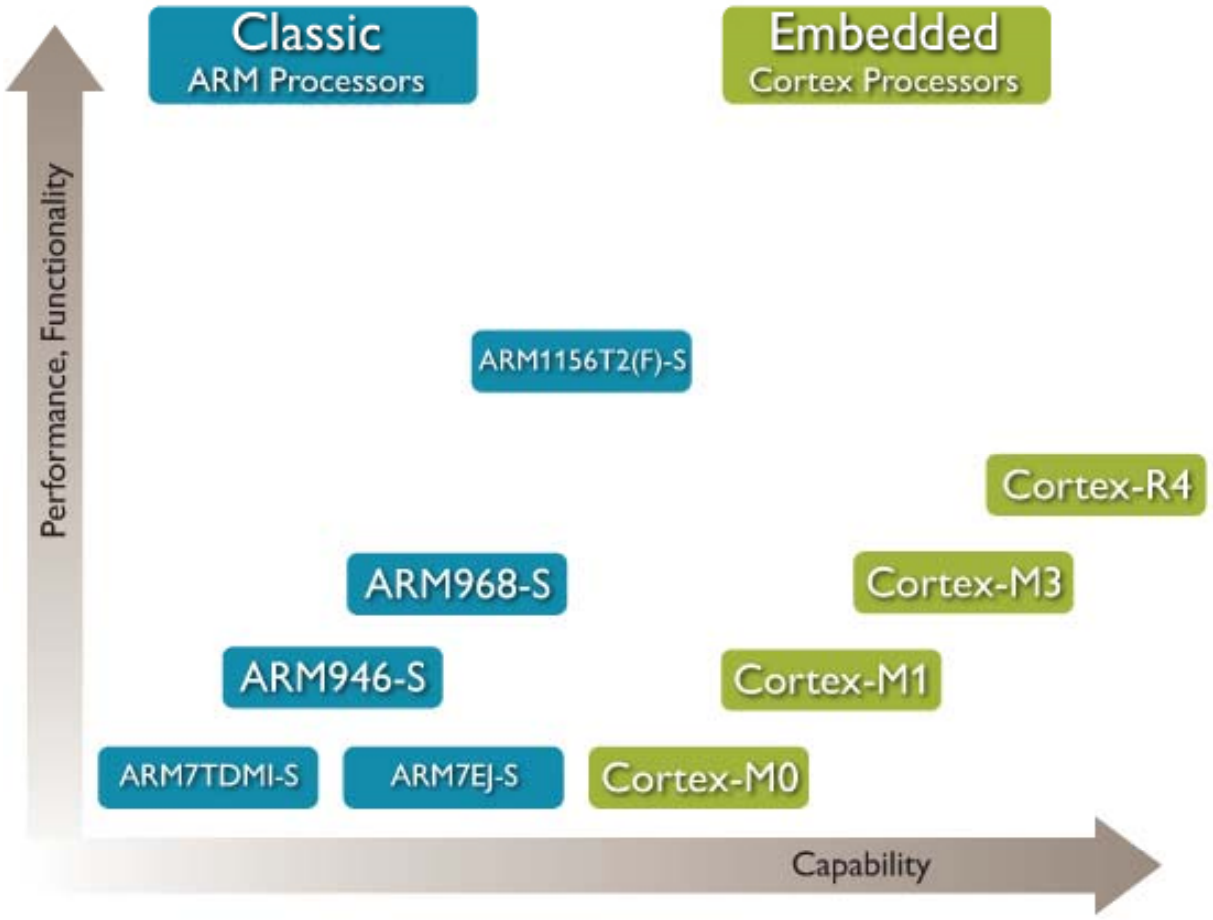
- **ARM7TDMI**
  - This is ARM7 family processor, which has T=thumb instruction set, D = Debug unit, M= MMU, I = trace circuit is inside the core (Embedded Trace Macrocel)
- This is basic core and all core have TDMI.
- **ARM946E-S**
  - ARM9xx core
  - **E**nhanced instruction set for DSP
  - **S**ynthesizable

ARM Processor



ARM Processor

- Classic processors (ARM7, ARM9, ARM11) and Embedded Cortex processor are specially designed for Embedded Application



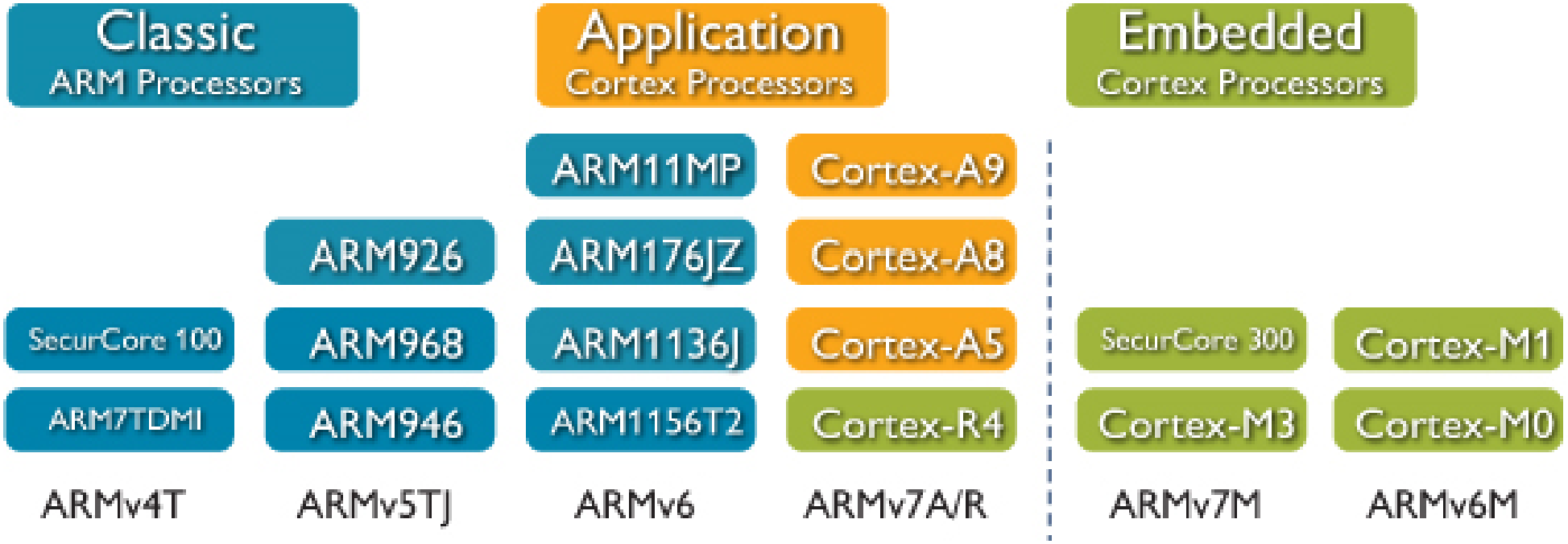
ARM Processor Architecture (ARM core) 1/2

ARM CORE	Feature
ARM v1 (obsolete)	26 bit instructions, no multiply or coprocessor
ARM v2 (obsolete)	32 bit result , added co processor
ARM v3 (obsolete)	32 bit instructions
ARM v4 **ARM v4T**	Add signed instructions, signed load and store instructions Thumb mode is added
ARM v5TEJ	Add Support for DSP algo and Jave byte code engine (Jazelle)
ARM v6	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

ARM Processor Architecture (ARM core) 2/2

<table>
<tr><th>ARM CORE</th><th colspan="3">Feature</th></tr>
<tr><td>ARMv6M</td><td colspan="3">Targeted for low cost high performance device.
Used in Cortex-M0 and Cortex-M2 series processors</td></tr>
<tr><td rowspan="2">ARM v7</td><td colspan="3">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 porifle</td></tr>
<tr><td>Cortex-A
MMU and optional support for NEON</td><td>Cortex-R
Realtime profile implementing a protected memory system architecture based on an MPU (Memory Protection Unit)</td><td>Cortex-M
Designed for fast interrupt processing and ideal for cost-sensitive devices requiring highly deterministic behaviour and minimal gate count.</td></tr>
</table>

ARM Processor Architecture (ARM core)



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 know 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

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

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 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**

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/)
  - 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

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)
  - 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 (3)

- **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)
  - 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.sourceware.org/)
- **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**

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

- **ARM Page @EmbeddedCraft**
  - http://embeddedcraft.org/arm.html#top

EmbeddedCraft
crafting of intelligent systems

Reference

- **ARM website**

  http://www.arm.com

- **GNUARM**
  - http://www.gnuarm.com/
- **Wikipedia**
  - http://en.wikipedia.org/wiki/ARM_architecture
- **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
  - YouTube 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

http://www.embeddedcraft.org/