



# Applications & Tools

# Introduction

- The ARM processor was first developed (between 1983 and 1985) by Acorn Computers, Ltd., based in Cambridge (UK).
- ARM designers were heavily influenced by Berkeley RISC I.
- In 1990, ARM Ltd. was founded by Acorn, Apple and VLSI.
- Several versions of ARM processors were designed in the following years.
- Today, ARM cores are widely popular among SoC designers, mainly because they show a very good tradeoff between performance and power consumption.
- ARM does not manufacture silicon
- More information about ARM on the web site:
  - <http://www.arm.com/aboutarm/>

# A few iconic products based on Arm Architecture

Some of them with processors developed by local Arm team

- Nokia 3310 (2000)
  - ARM7TDMI (150-250MHz)
- Playstation Vita (2011)
  - Cortex-A9 MP Core
- Galaxy watch 4 (2018)
  - Cortex-A55 (1.18Ghz) – GPU Mali G68
- Samsung Galaxy S22 (2022)
  - Cortex-X2 (3GHz) + Cortex-A710 + Cortex-A510
- Graviton3 (2020)
  - Neoverse-V1



# ARM Offices Worldwide



# ARM processors

- They are mainly sold as cores, to be used for integration in Systems on Chip (SoCs).
- Cores can be
  - *Hard cores*: ARM provides a physical layout implemented in a given technology
  - *Soft cores*: ARM provides a high-level description that can be then synthesized to any technology by the designer.
- In a few cases, ARM processors have been delivered as stand-alone devices.

# ARM is everywhere

**70%**

of the world's population  
uses Arm technology

**280+bn**

Arm-based chips shipped  
to date

**95%**

of the world's smartphones  
are based on Arm

**50%**

of automotive MCUs are  
powered by Arm-based SoCs

**55%**

of consumer devices are  
powered by Arm IP

**100x**

compute increase  
since 2009

**90%**

of wearables powered  
by Arm-based SoCs

**20+bn**

Arm-based cellular  
modems shipped to-date

# ARM processor families

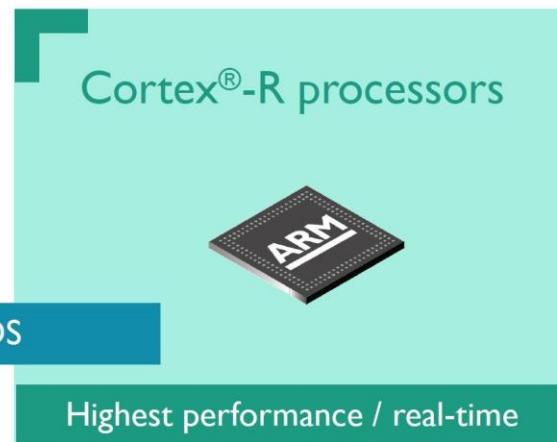
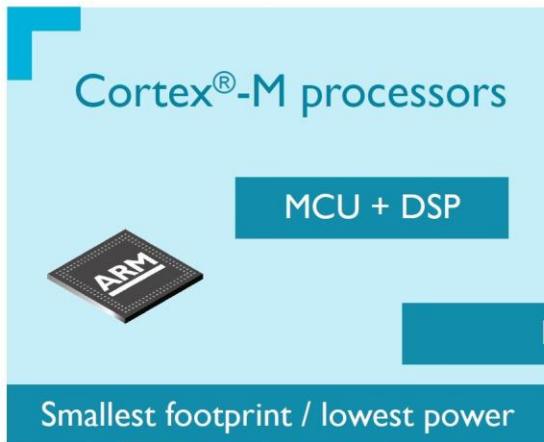
- Application-Class CPU
  - Smartphones
  - Datacenters/Cloud/HPC
- Real Time Class CPU
  - Brake systems
  - Avionics, Automotive
  - Medical devices
- Embedded Energy efficient
  - Embedded in other chips
    - ASICs
    - Microcontroller
    - IoT

Cortex A

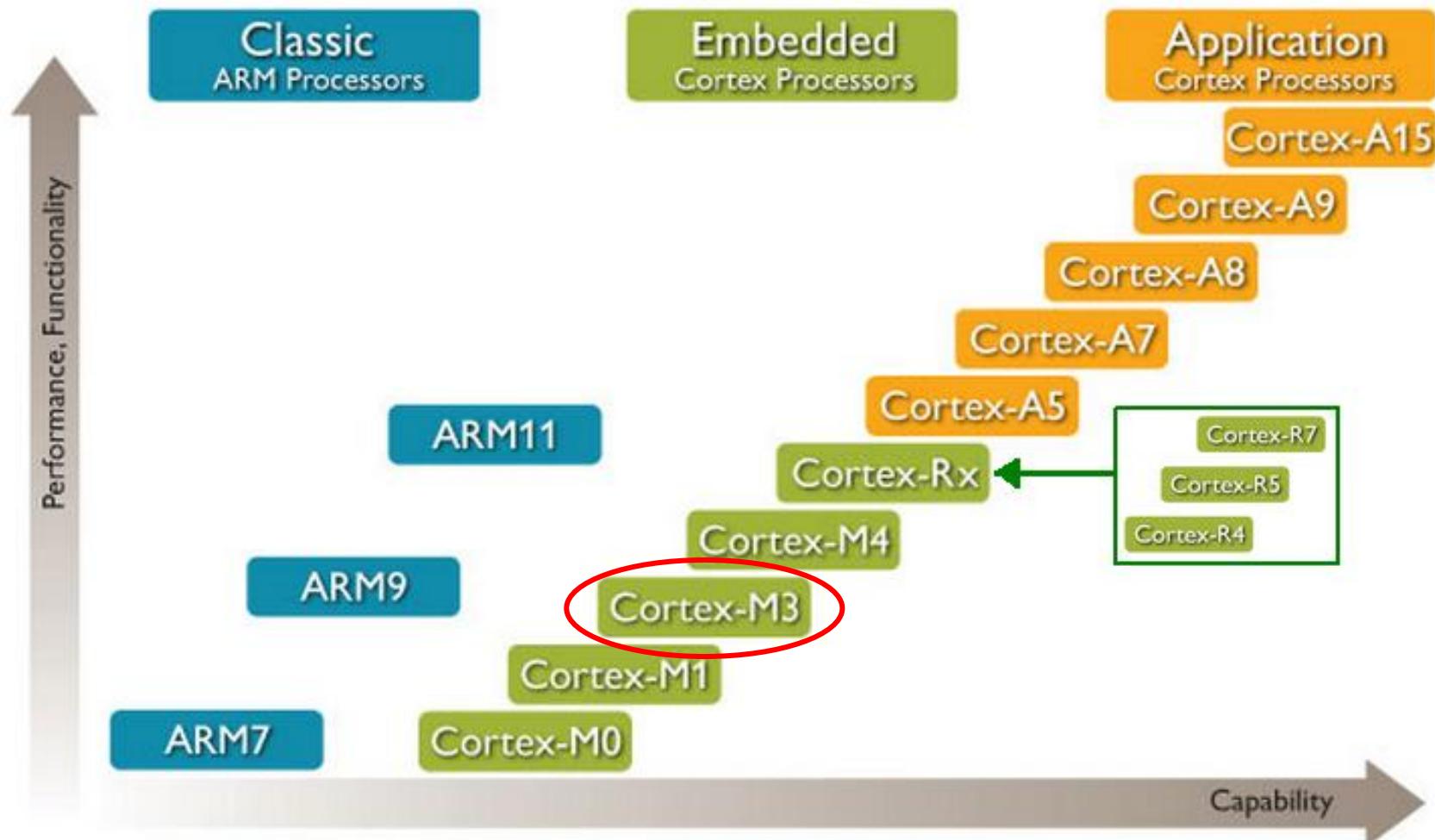
Cortex R

Cortex M

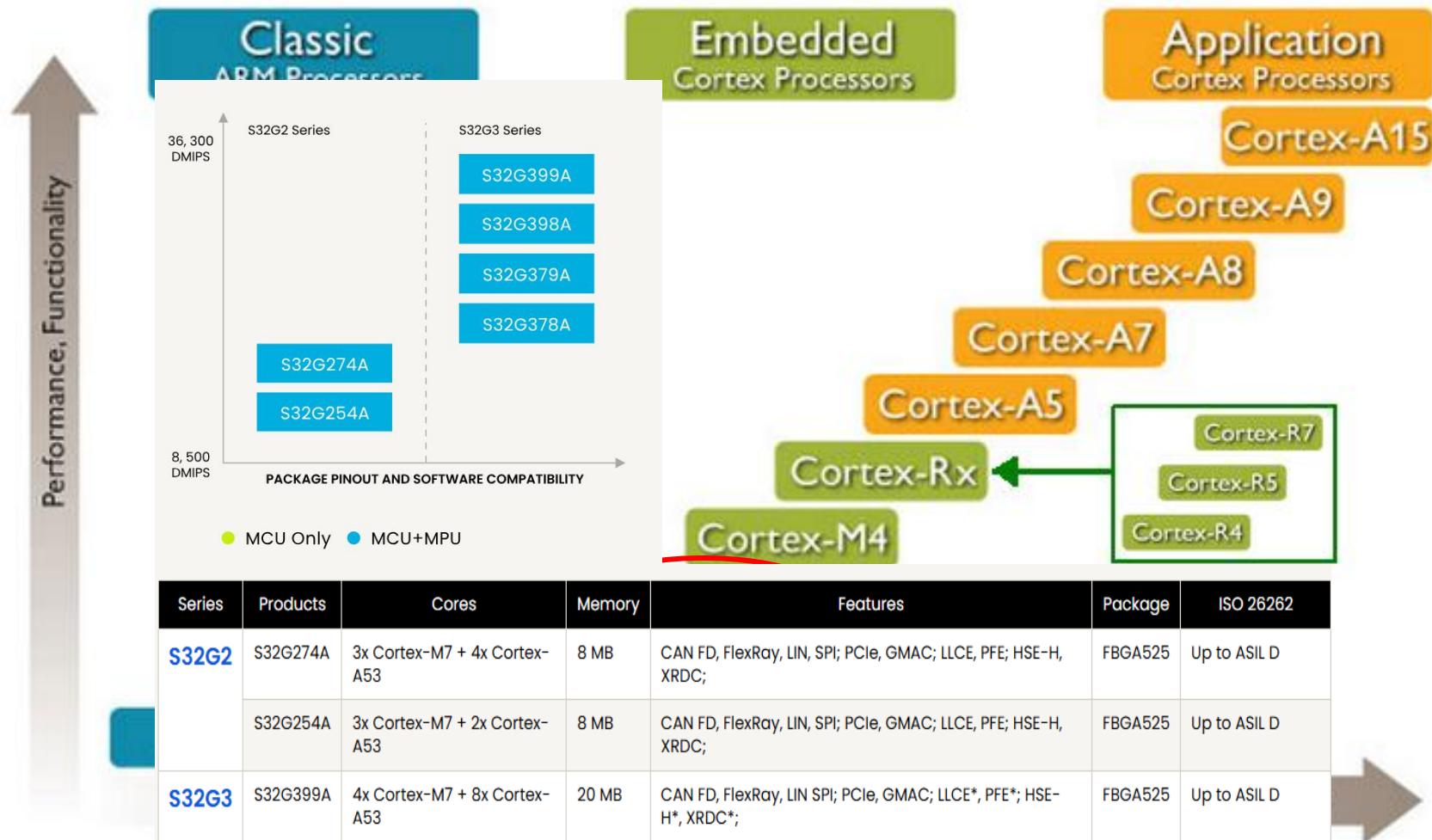
# ARM processor families



# ARM processors



# ARM processors



## Silicon Partners



## Design Support Partners



## Software, Training and Consortia Partners



cadence®

synopsys®  
Silicon to Software™

Paolo BERNARDI



IBM

Windows Embedded

Green Hills SOFTWARE

ubuntu

redhat

vmware

KEIL  
Tools by ARM

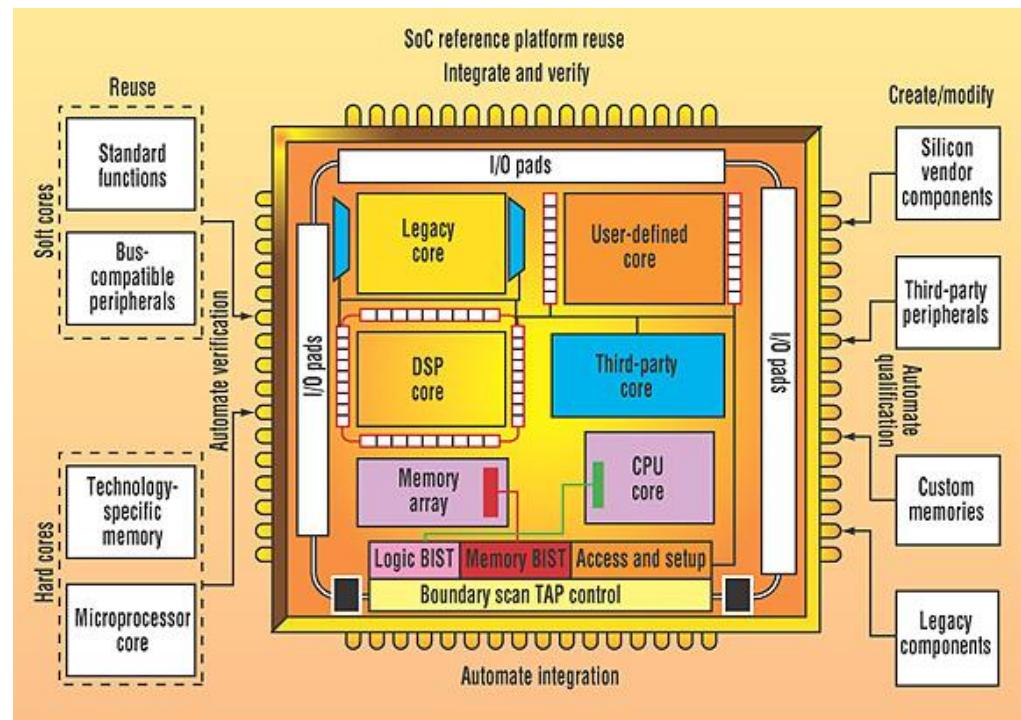
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# ARM world

- ARM architecture embedded in System-on-chip (SoC)
- ARM Operating Systems
- ARM Compile – Support – Debug tools

# System-on-Chip (SoC)

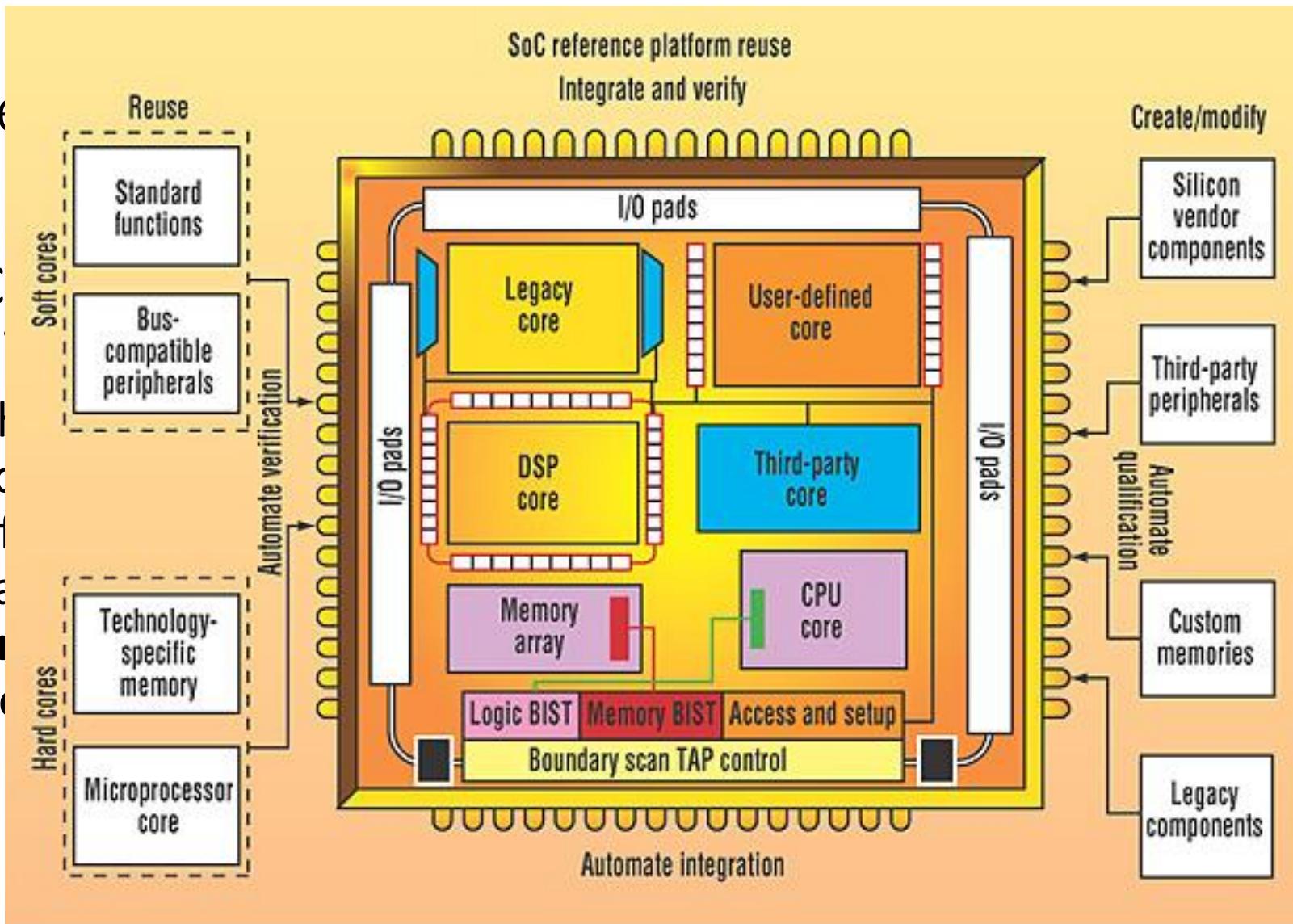
- SoCs are entire systems integrated in a single piece of silicon
  - They are composed of modules called **Embedded Cores**.



1. This diagram shows a usual SoC derivative built from a reuse platform in which over 70% of the design content could come from reuse.

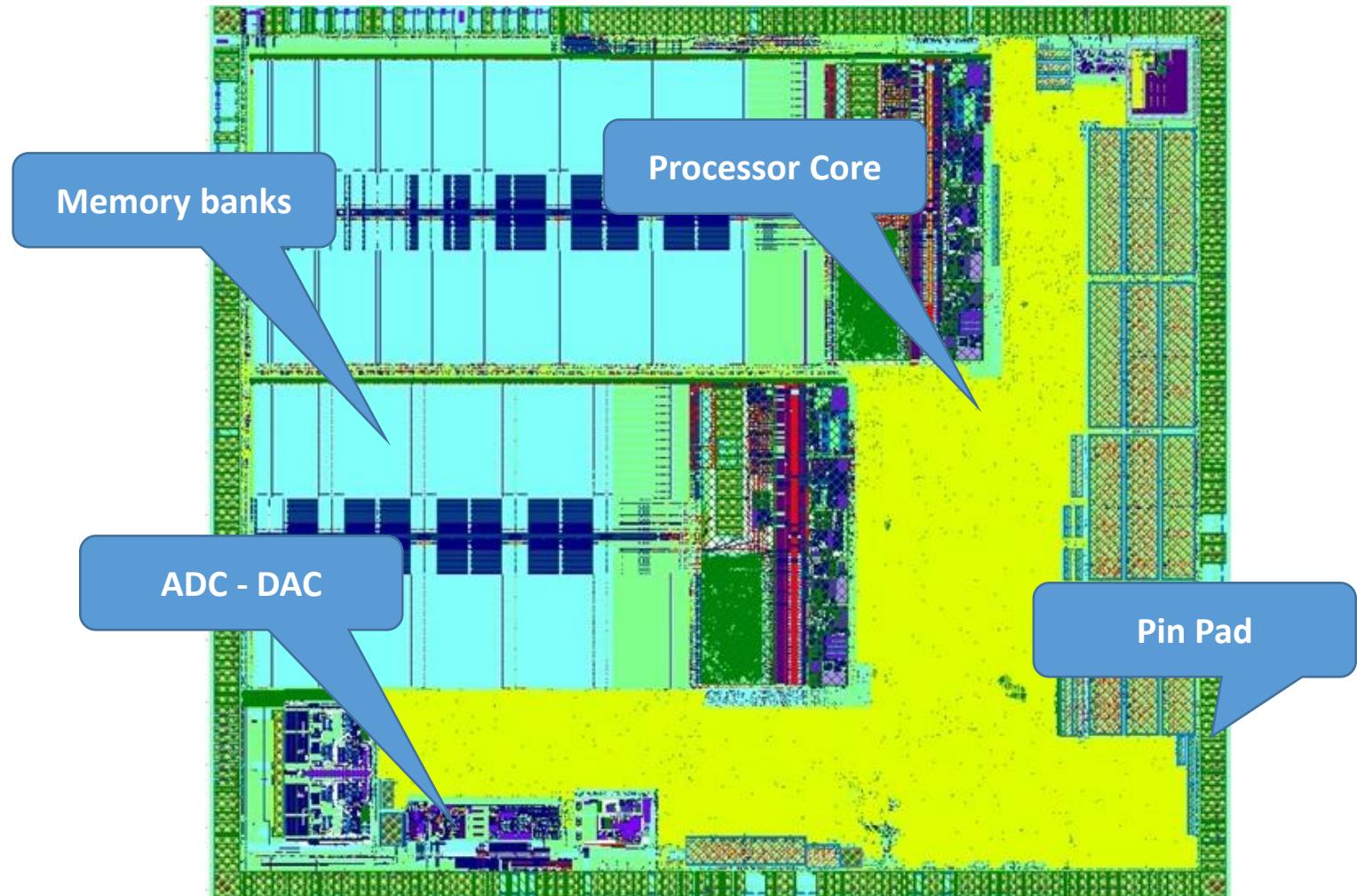
# System

- SoC  
of s
- Th  
co  
ot  
ca  
E  
Co



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# SoC layout example



# ARM-based commercial SoCs

- *SAMSUNG:*  
[http://www.samsung.com/global/business/semiconductor/products/mobilesoc/Products\\_ApplicationProcessor.html](http://www.samsung.com/global/business/semiconductor/products/mobilesoc/Products_ApplicationProcessor.html)
  - <http://pdf.datasheetcatalog.com/datasheet2/e/0lrp9fdj0zyd6e2k2e8ej8lkzupy.pdf> (page 35)
- *NXP:* <http://www.standardics.nxp.com/microcontrollers/>
  - [http://www.nxp.com/documents/data\\_sheet/LPC1769\\_68\\_67\\_66\\_65\\_64\\_63.pdf](http://www.nxp.com/documents/data_sheet/LPC1769_68_67_66_65_64_63.pdf) (page 6)
- *STMicroelectronics:* <http://www.st.com/mcu/>
  - [http://www.st.com/st-web-ui/static/active/en/resource/technical/document/datasheet/CD00067905.pdf?s\\_searchtype=keyword](http://www.st.com/st-web-ui/static/active/en/resource/technical/document/datasheet/CD00067905.pdf?s_searchtype=keyword) (page 8)
  - [http://www.st.com/mcu/contentid-34-86-STR710\\_EVAL.html](http://www.st.com/mcu/contentid-34-86-STR710_EVAL.html)
- ...and many others...

# ARM compliant Operating Systems

- Microsoft Windows CE:

<http://www.microsoft.com/presspass/press/2002/sep02/09-18armsummitpr.mspx> (old news removed)

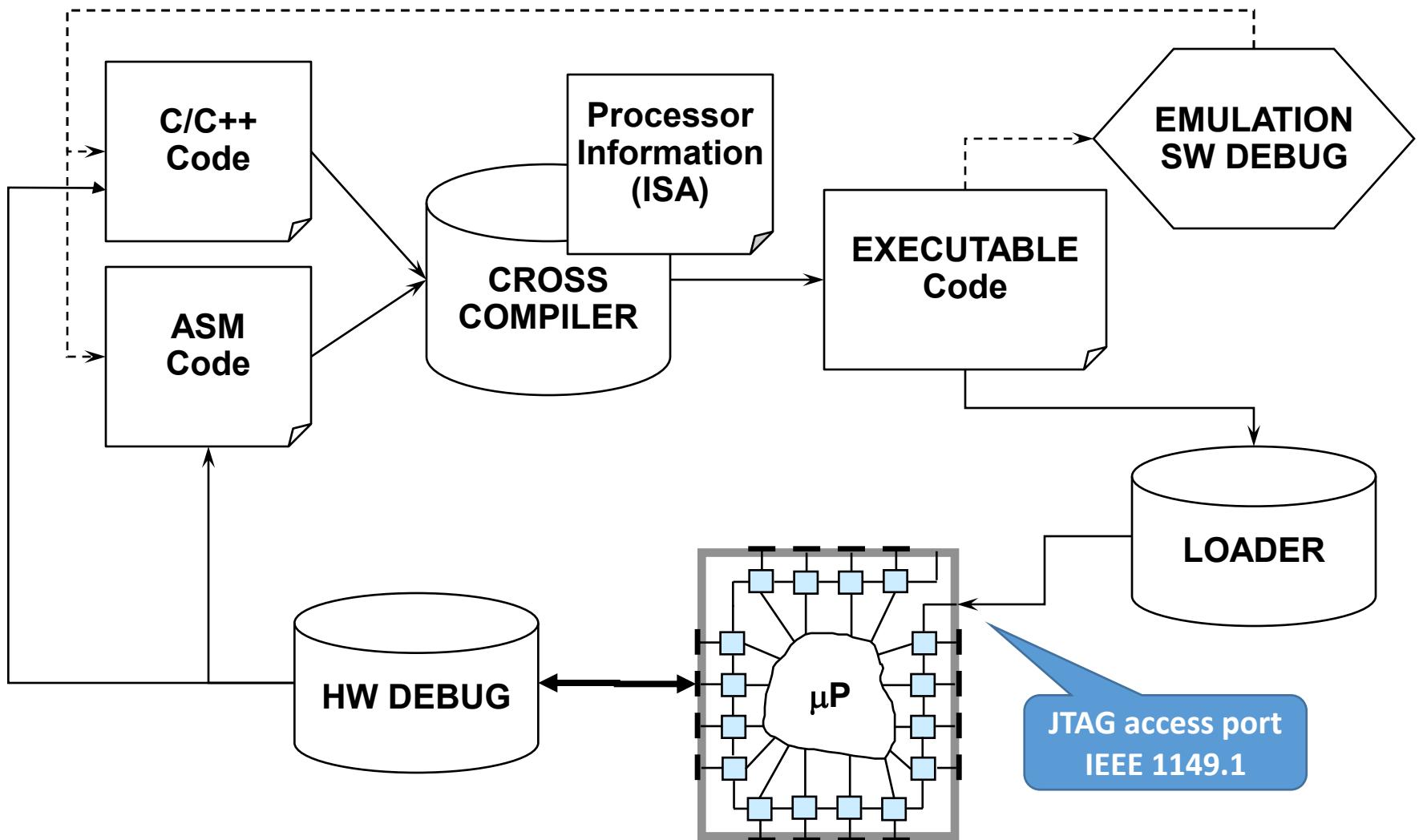
- Linux: *many releases*

- <http://www.debian.org/ports/arm/>
- plenty of kernel to be customized
- WIKI for problem solving

**Das U-Boot:**  
<http://sourceforge.net/projects/u-boot/>

All of them  
requires a  
**bootloader**  
to be  
launched

# Tool chain



# ARM Tool chain

- CROSS-COMPILEATION/EMULATION/SW DEBUG
  - WINDOWS: <http://www.keil.com/>
  - LINUX:  
[http://www.codesourcery.com/gnu\\_toolchains/arm](http://www.codesourcery.com/gnu_toolchains/arm)
- LOADING TOOLS
  - Ad-hoc tools released with products:
    - <http://www.keil.com/>
  - Generic and customizable tools
    - OPENWINCE: <http://openwince.sourceforge.net/>
- HW DEBUG TOOLS
  - Based on internal debug structures such as ***Embedded ICE***
    - <http://infocenter.arm.com/help/index.jsp?topic=/com.arm.doc.dai0201a/index.html>

Based on  
IEEE 1500  
HW structures

# What do we learn in this part of the course

- ARM assembly principles
  - Instruction Set Architecture
  - C + ASM programming by following ABI standards
  - System-on-Chip level programming including
    - Peripheral management
    - clock and power modes management
- Internal, SW and HW interrupts management
  - Exceptions due to unexpected execution flaws
  - SW interrupts towards system call understanding
  - HW interruptions
    - Possible sources of hw interrupt including internal modules (i.e., timers) and external events (i.e., button pression)
    - Interrupt controller behavior
- Extended system on-board features.

# Case of study

- **Landtiger board**

- Based on a NXP system-on-chip

**LPC1768**

including a ARM 32-bit Cortex-M3 Microcontroller with a full set of on-chip peripheral cores

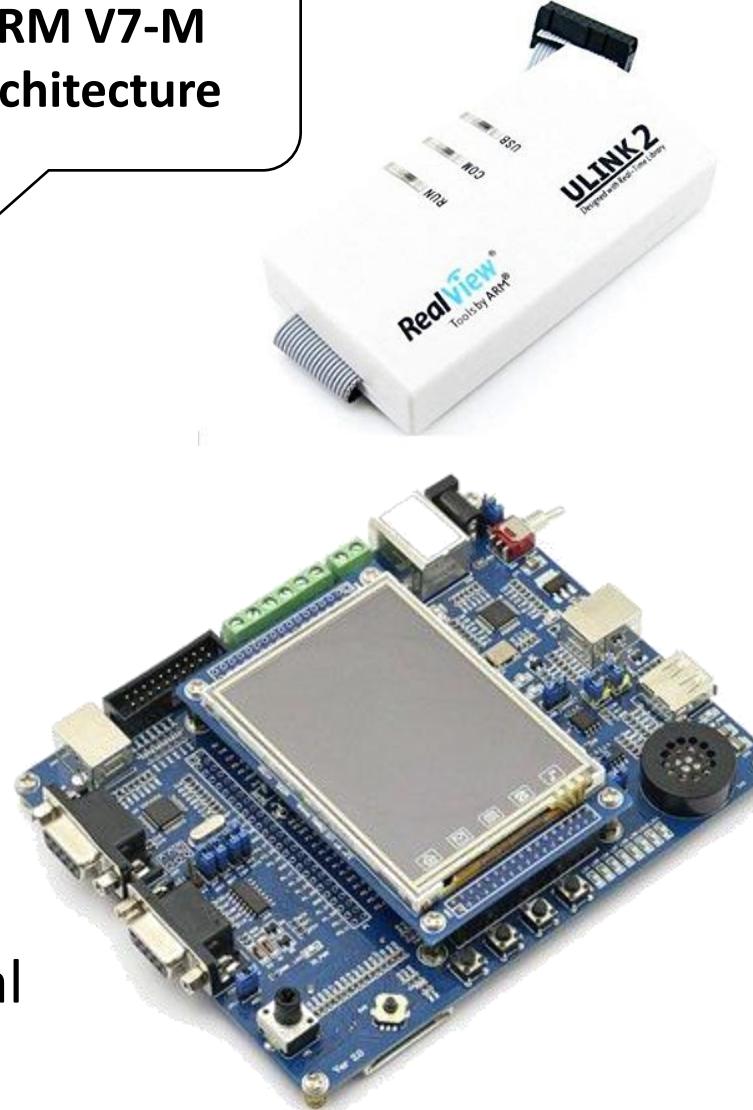
- Mounting several additional devices and connectors on board

- KEIL uVision software

- Trial version with 32K code limitation
- Full use of the debugging features
- Very accurate timing calculation

- HW debug enabled by an additional component called real-view, which implements a ULINK2 jtag based connection.

ARM V7-M  
Architecture



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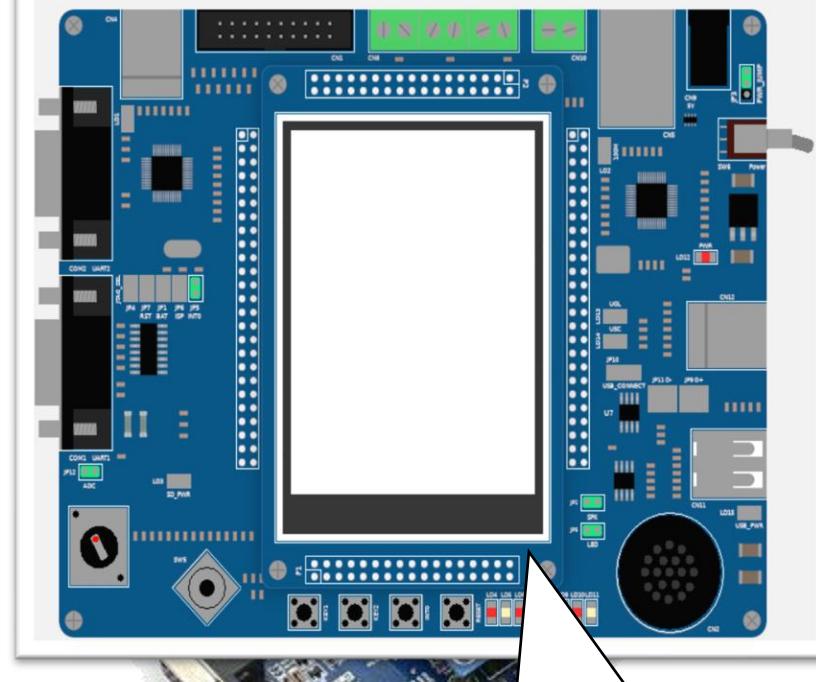
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**ARM V7-M  
Architecture**

Politecnico di Torino - LandTiger Emulator v1.2-0



**Board Emulation  
system**