Embedded systems

- Somes French translations :
  - Systèmes embarqués
  - Systèmes enrobés
  - Systèmes enfouis

Embedded systems, definition

There is no formal definition of an ***embedded system***, but it is generally accepted to be a type of computer designed **to solve** a **specific problem or task**.

This is in contrast to a general-purpose computer such as a PC or workstation.

Embedded systems typically use a **microprocessor** combined with other hardware and software to solve a specific computing problem.

Embedded systems, definition

Microprocessors range from simple (by today's standards) **8-bit microcontrollers** to the worlds fastest and most sophisticated **64-bits microprocessors** or even more as **multi-core.**

Embedded system **software** ranges from a small executive to a large real-time operating system (RTOS) with a graphical user interface (GUI).

Typically, the embedded system software must **respond to events** in a **deterministic way** and should be guaranteed **not to crash**.

Embedded systems, definition

The embedded system landscape is as diverse as the world's population :

→ **no two systems are the same** ←

Embedded systems range from large computers such as an air traffic control system to small computers such as a handheld computer that fits into your pocket.

Jason Andrews

Embedded systems

- Some examples :
  - Camera
  - Video camera
  - Cars : ABS, ignition, acclimatization, etc..
  - Portables Phones → Smartphones
  - PDA (Personal Digital Assistant) → Tablet
  - …

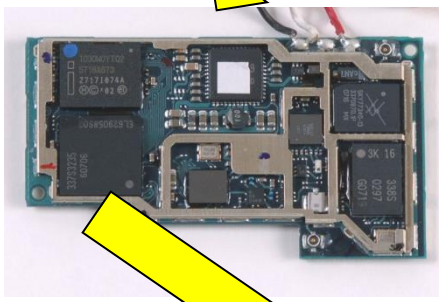
Interfaces and peripherals:
→ some embedded systems

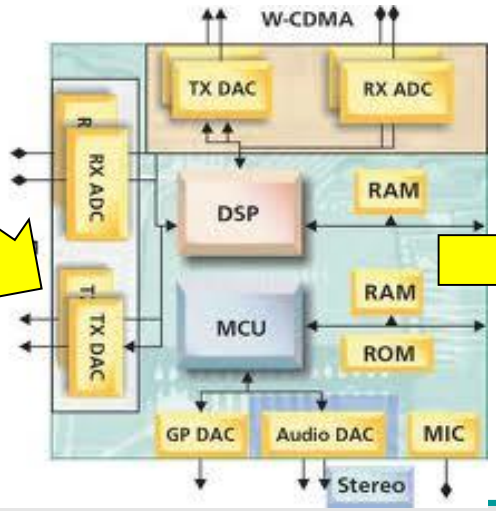
http://www.espace-pc.fr/peripheriques.html

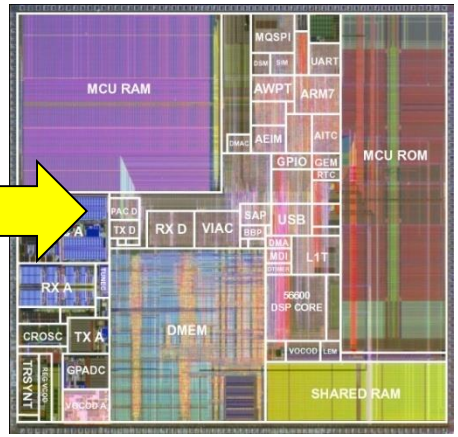
Processors categories

- Processors: **Softcore vs hardcore**
- Reconfigurable Processors (Xtensa, [Tensilica])
- Microcontrollers (8051, HC12, STxx, …)
- PSOC, Programmable Syst. On Chip (Cypress)
- Embedded controller (68xxx, ColdFire, ARM, PowerPC, …, 8051, HC12, STxx, ...)
- Processors on FPGA (Altera, Triscend, Xilinx, AVR, …), **Softcore** (NIOS [Altera], microblaze [Xilinx]) **or hardcore** (ARM, PowerPC, …)
- DSP (Digital Signal Processor)

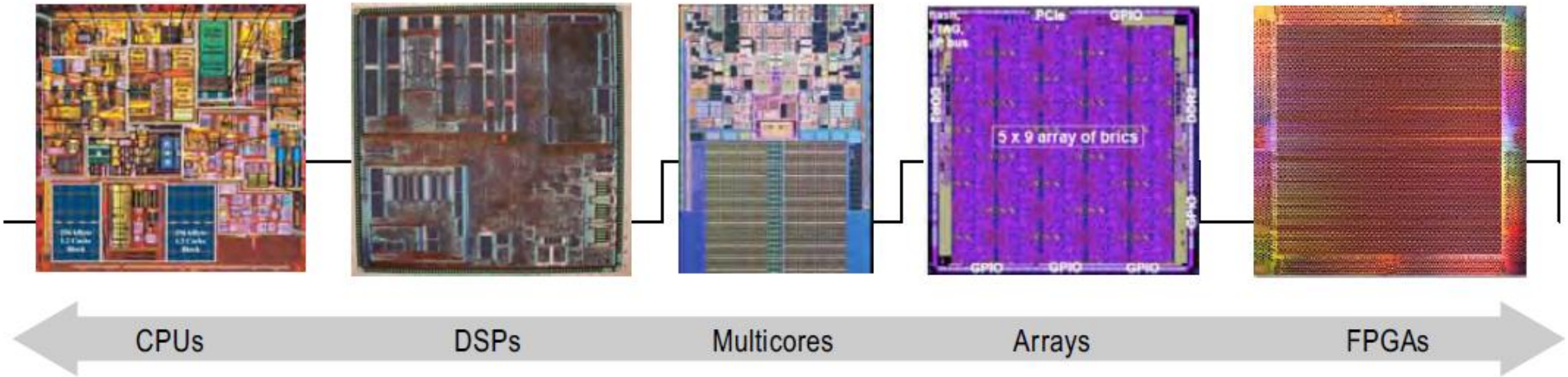
Processors




W-CDMA
TX DAC
RX ADC
RX ADC
DSP
RAM
RAM
MCU
ROM
TX DAC
GP DAC
Audio DAC
MIC
Stereo


MCU RAM
MQSPI
UART
AWPT
ARM7
AEIM
AITC
MCU ROM
GPIO
GEM
RTC
PAC D
TX D
RX D
VIAC
SAP
BBP
USB
DMA
MDI
L1T
RX A
56600
DSP CORE
CROSC
TX A
DMEM
GPADC
VOCOD
LEM
TRSYNT
SHARED RAM

Some Processors architecture & technology



http://www.altera.com/literature/wp/wp-01173-opencl.pdf

General Architecture → SOC System On Chip

- A **µC** (microcontroller) is an integrated circuit with all the elements of a Computer System include on ONE chip:
  - Processor(s)
  - Memory (memories)
  - Programmable Interfaces
- Some **µC** adds the capability to extend external memories and Progr. Interfaces, they have external Add/Data/Ctrl busses.

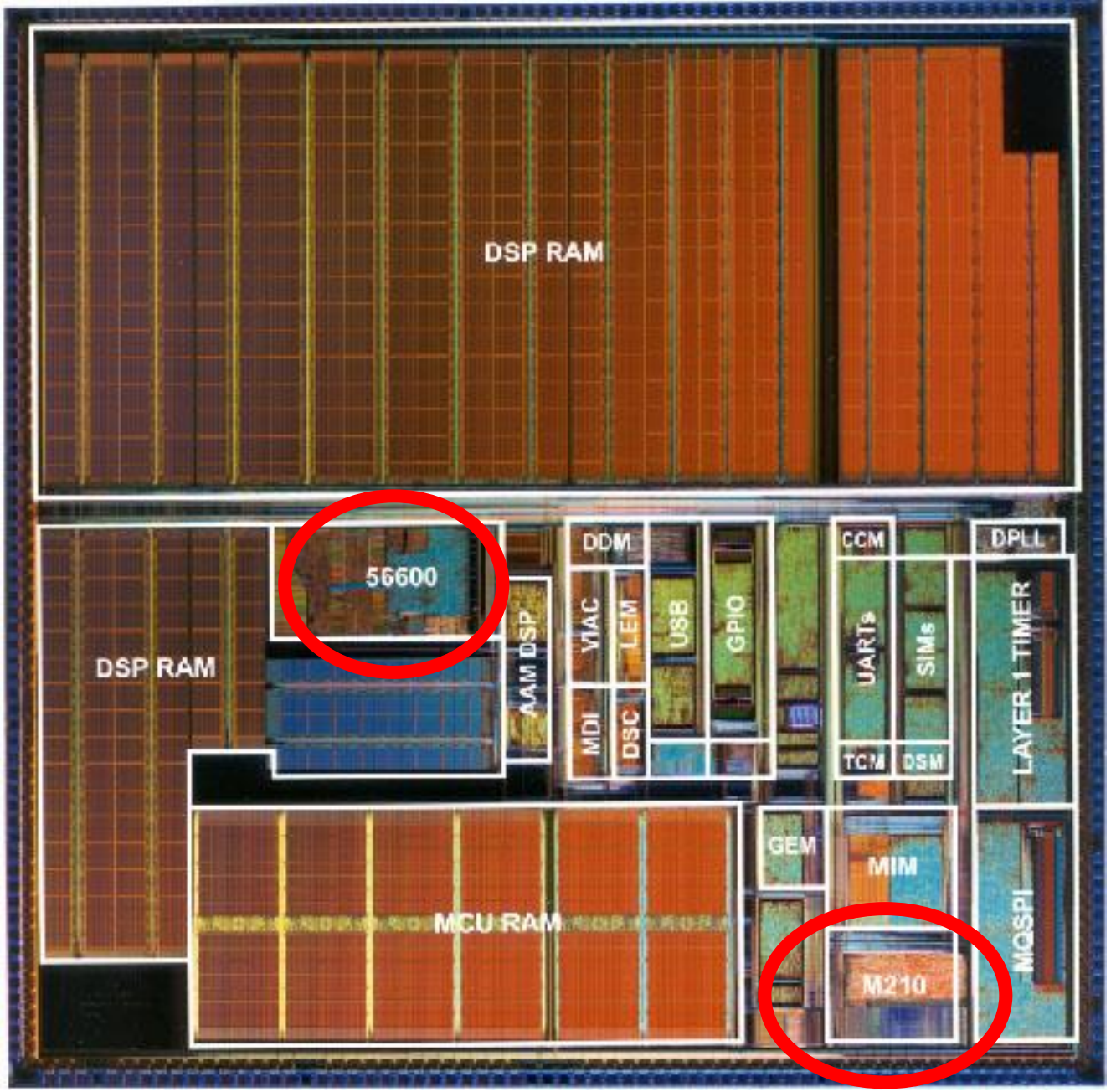
Some Programmable Interfaces

- Parallel ports
- Timer
- Analog to Digital Converter (ADC, ATD)
- Digital to Analog Converter (DAC)
- Pulse Width Modulation (PWM)
- Serial Interfaces:
  - UART (Universal Asynchronous Receiver/Transmitter)
  - SPI (Synchronous Peripheral Interface)
  - I2C
  - CAN
  - Ethernet
  - …
- …

Embedded communication

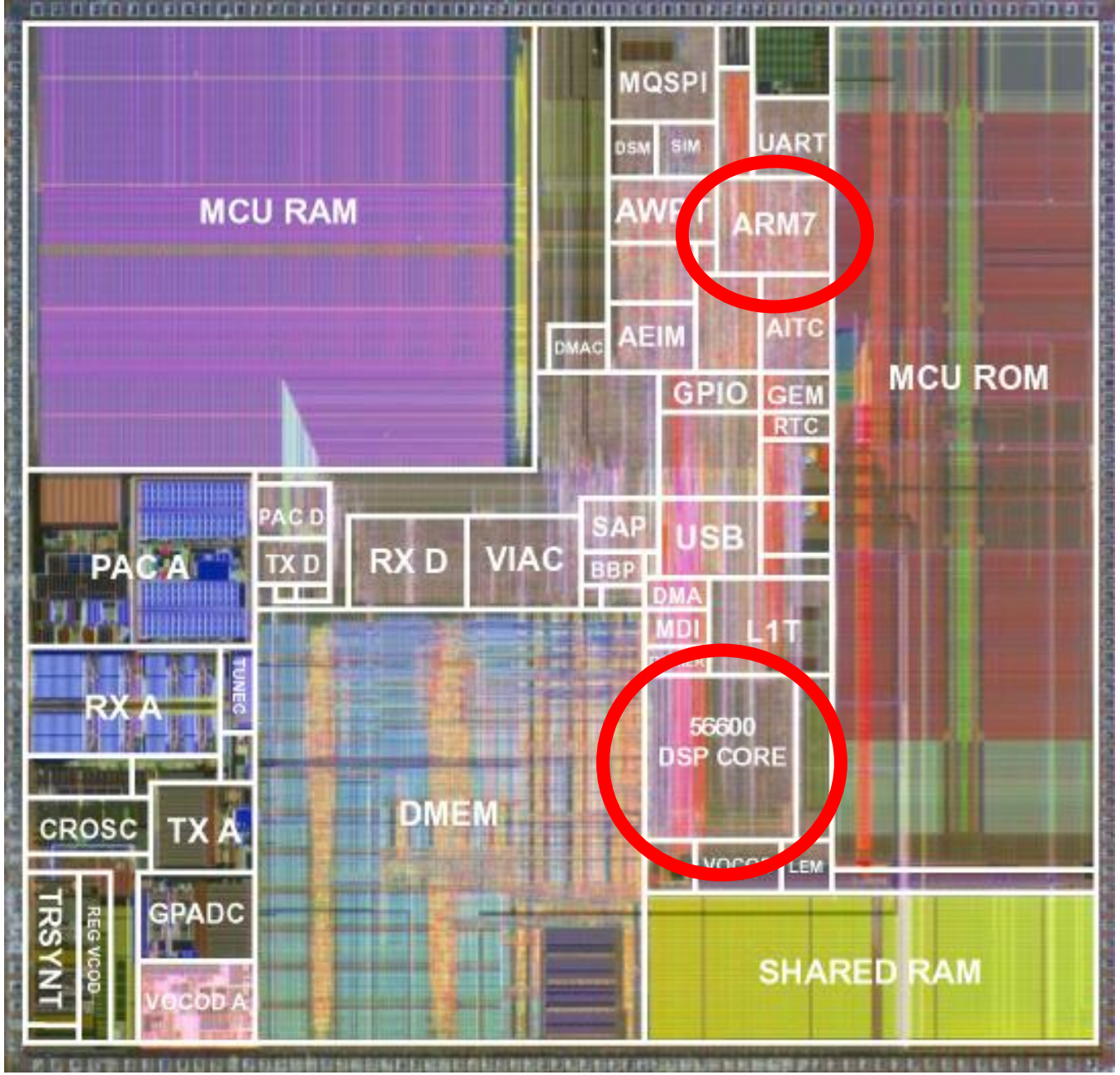
- Serial :
  - I2C, SPI, RS-232, IrDa
  - Ethernet
  - Wireless (Bluetooth, ZigBee, Wifi 802.11, …)
  - USB
  - Firewire, IEEE 1394
  - SATA
- Parallel :
  - PCMCIA
  - PCI

Baseband Chip



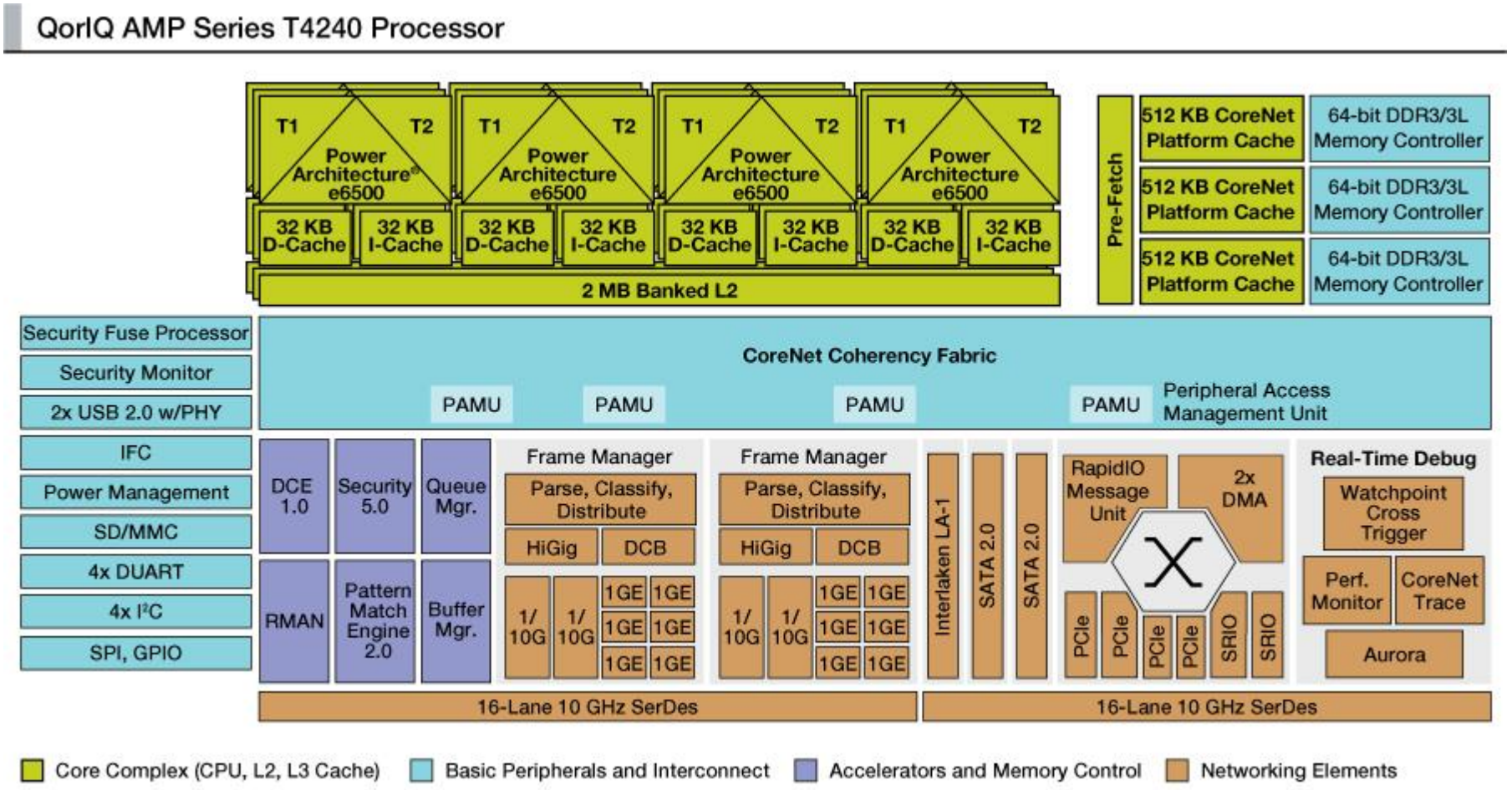
Courtesy of Motorola, © Motorola 2000

Baseband Chip



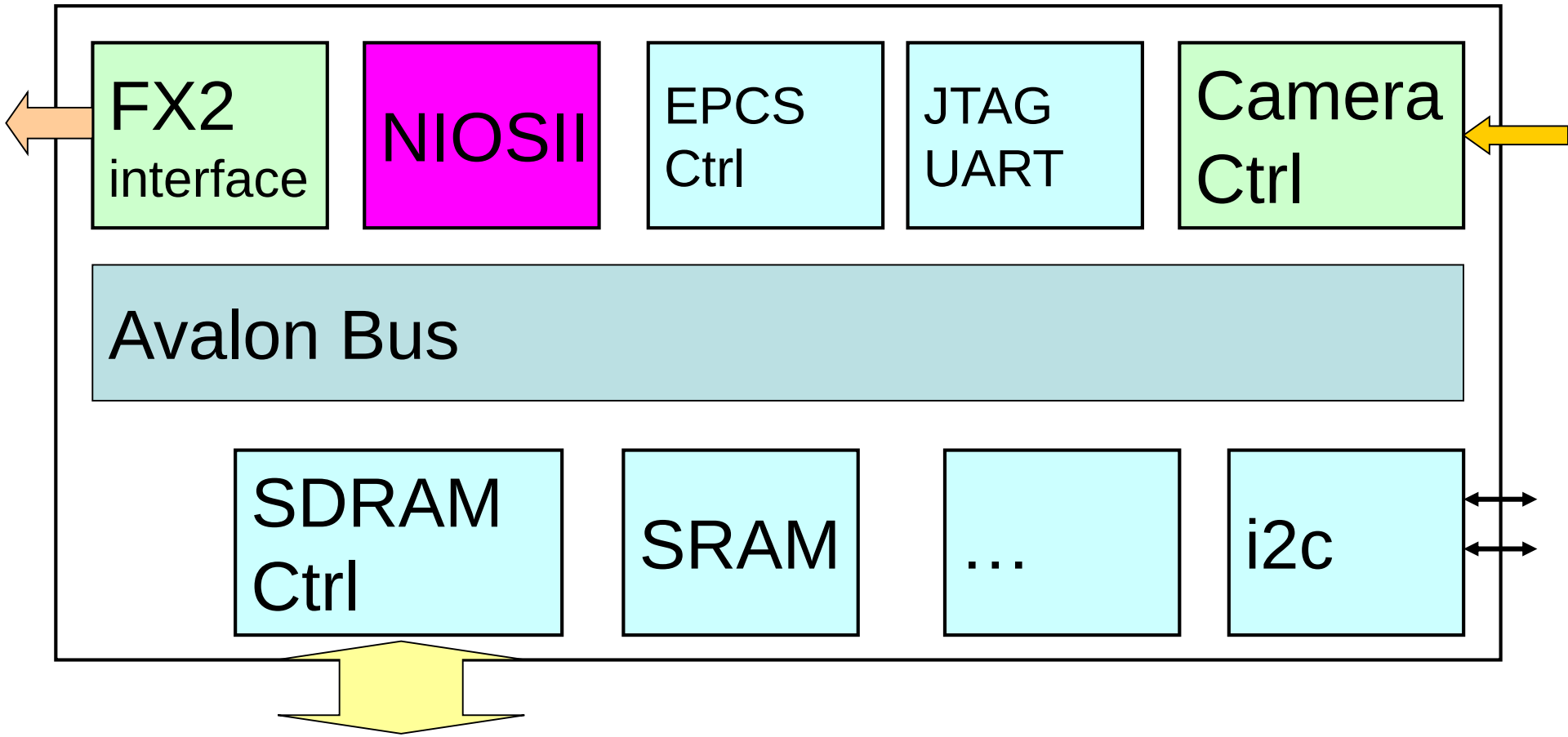
Courtesy of Motorola, © Motorola 2002

High Performance Processor, 12 cores

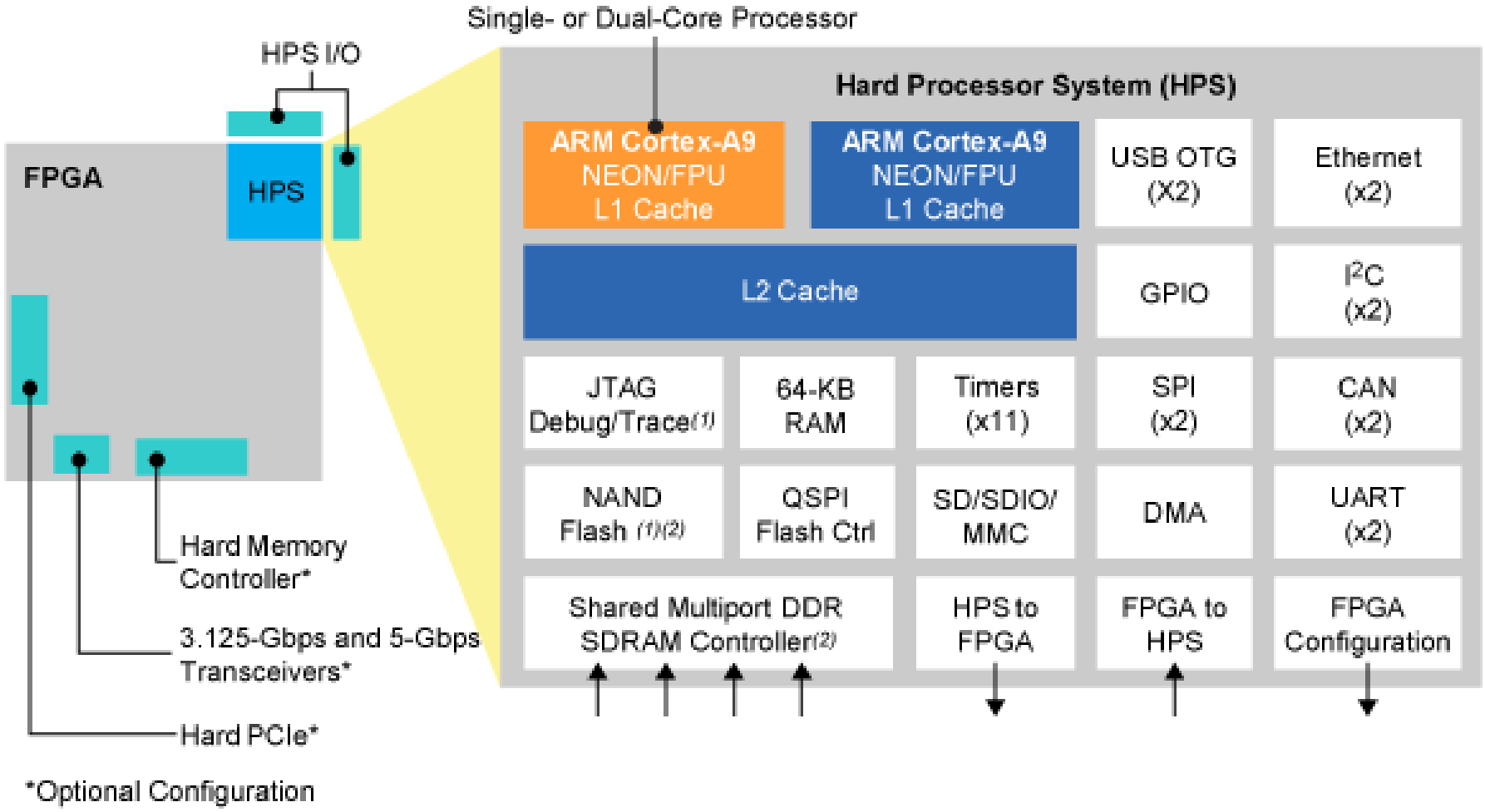


http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=T4240

Architecture FPGA

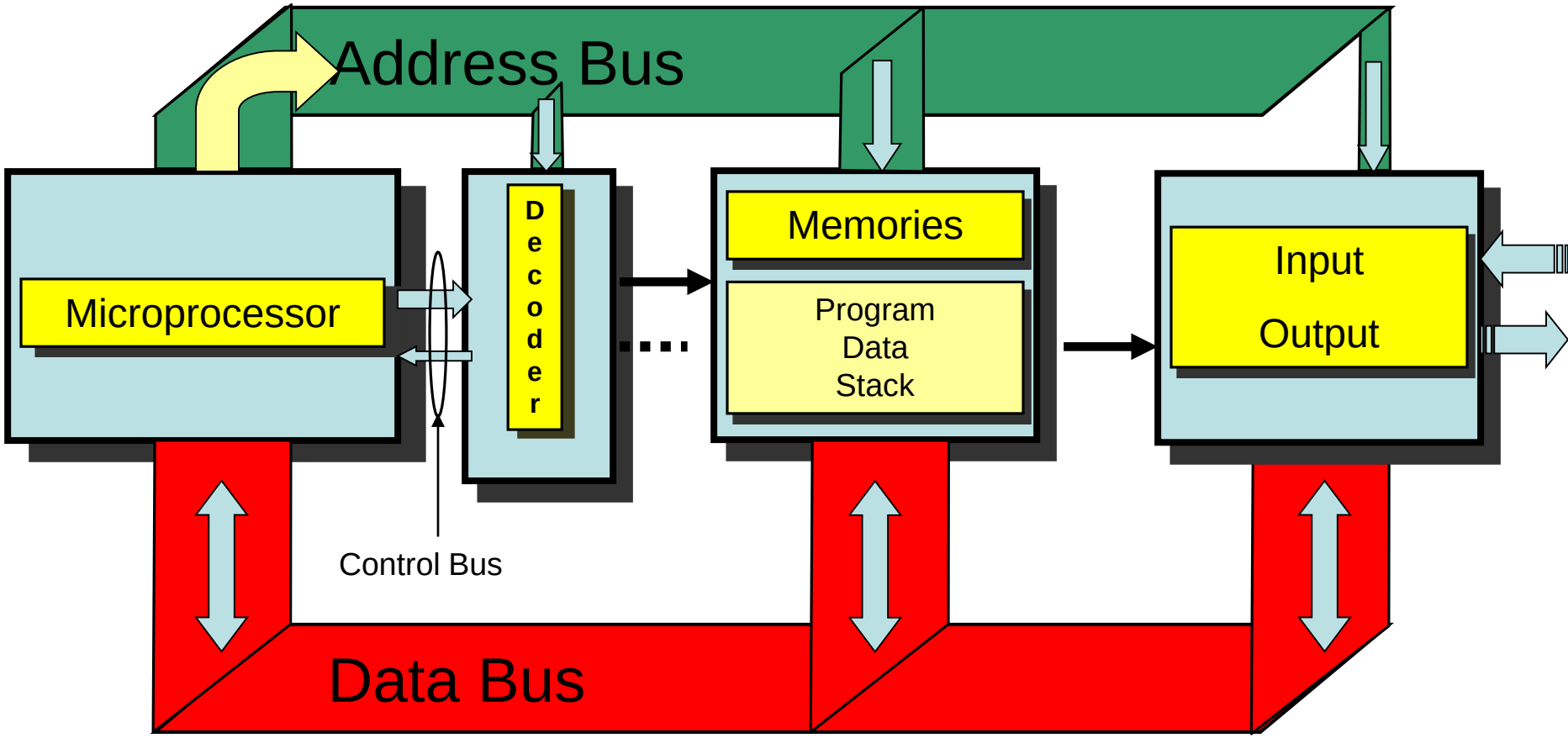


Architecture FPGA + Processor + Prog. Interfaces



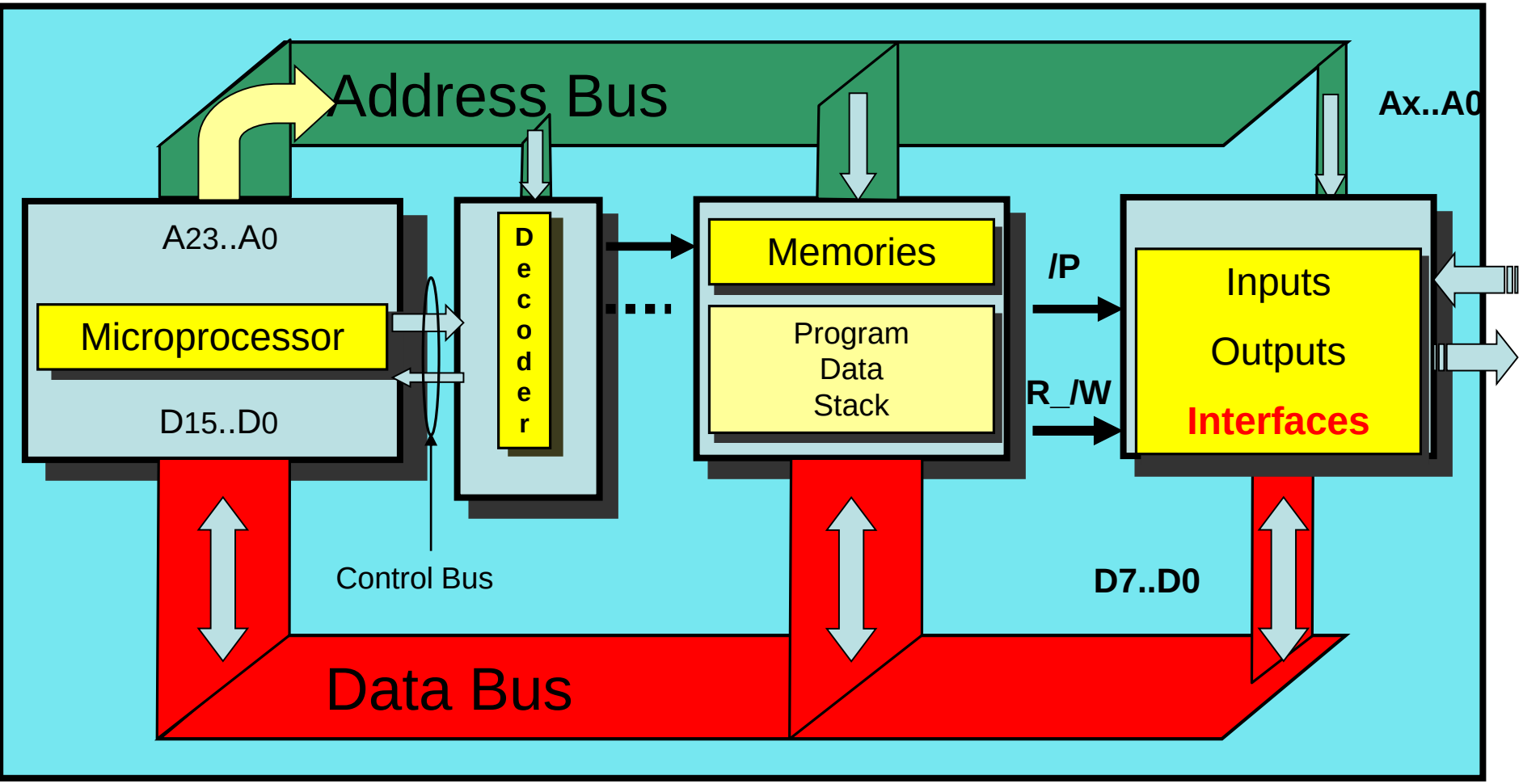
http://www.altera.com/devices/fpga/cyclone-v-fpgas/hard-processor-system/cyv-soc-hps.html

General computer systems

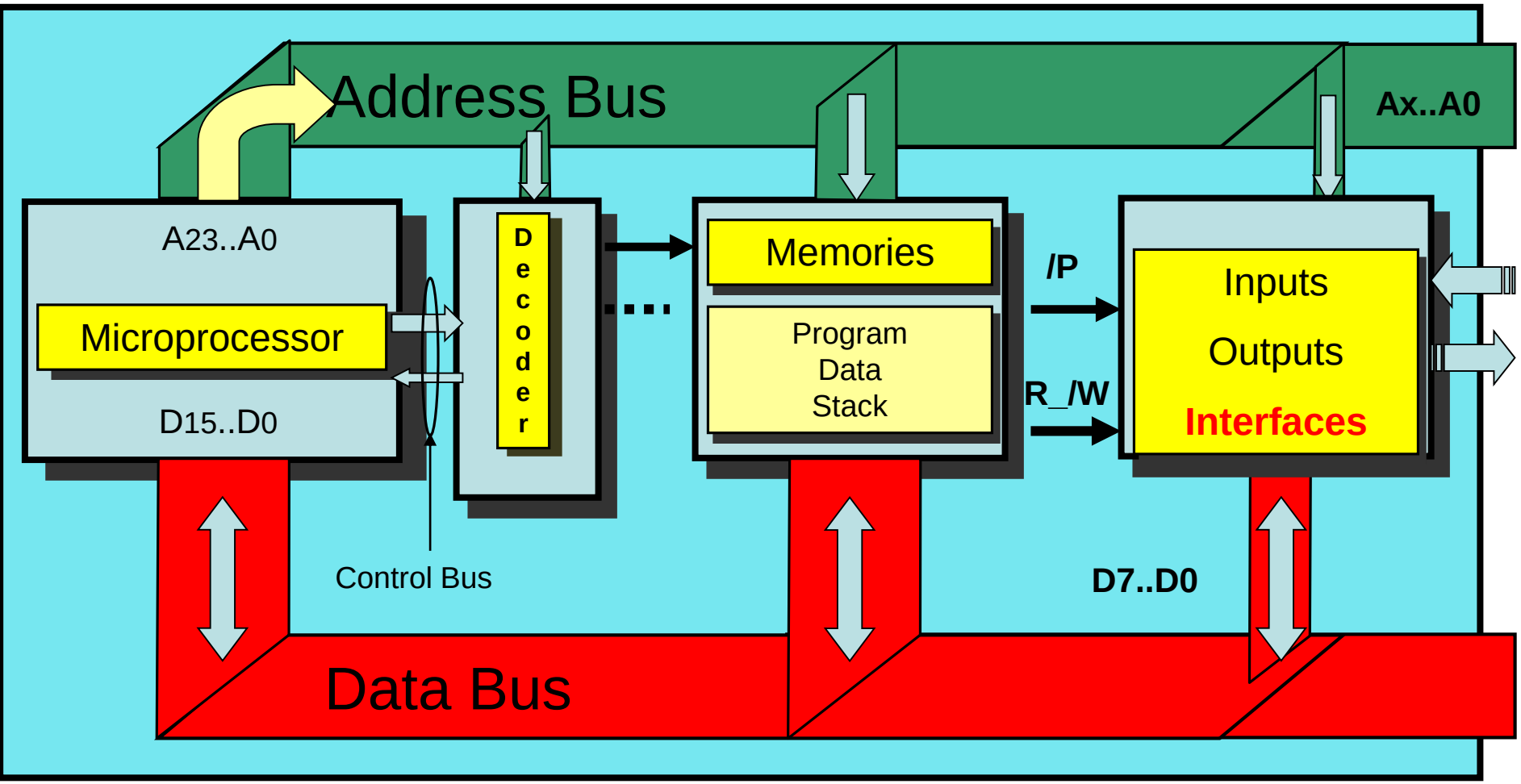


Very general architecture

General System Architecture, µController



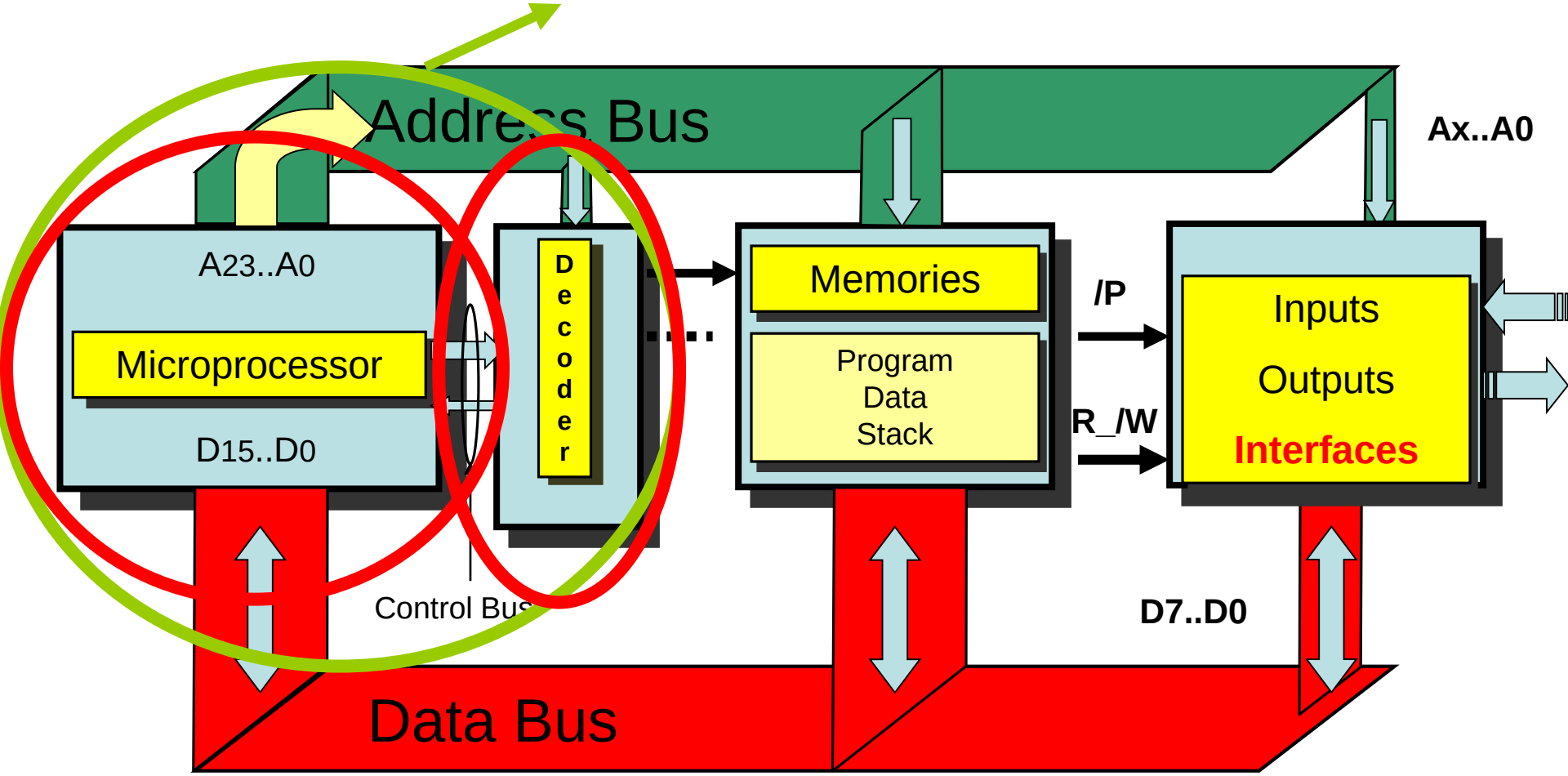
General System Architecture, µController + External bus



General Architecture

- Some circuits does not provides memory, only the processor and some programmable interfaces they are generally named **embedded processor.**

Embedded controller, ex. 68331

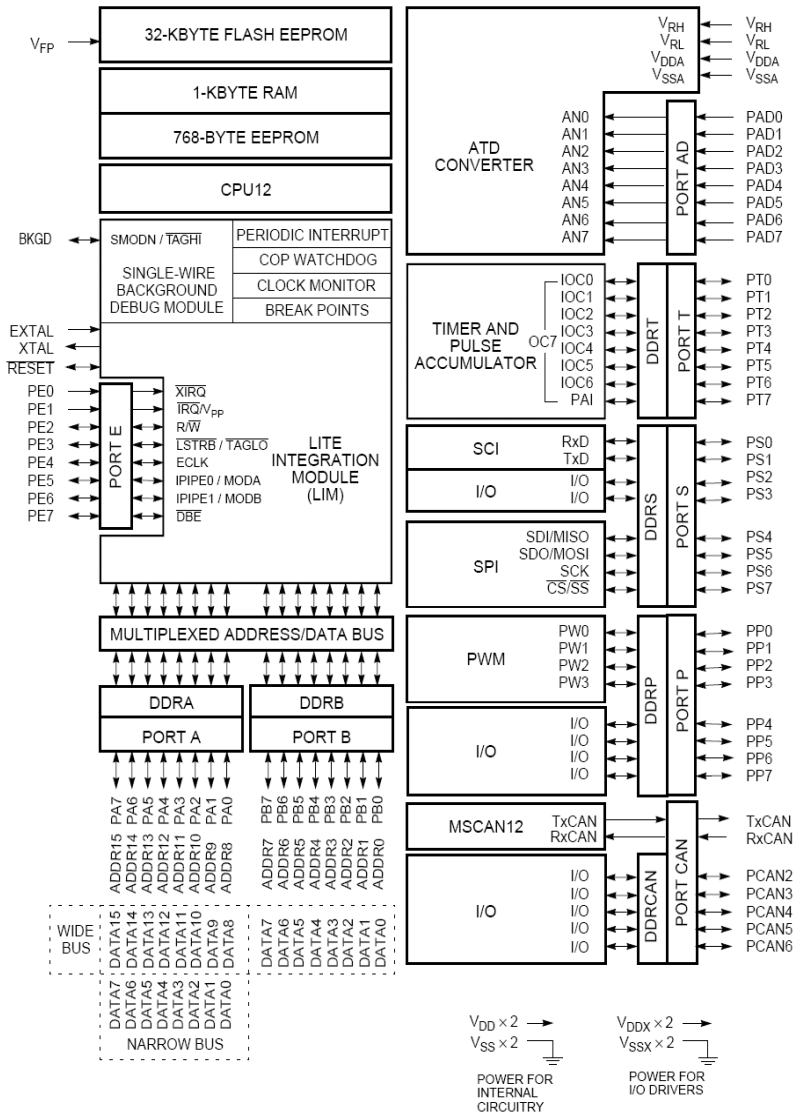


Some Very known Families of 8 bits µC

- 8051 based µC (intel → many manufacturer)
- AVR
- 68HC05, HC08, HC11, HC12 (Motorola → Freescale)
- PIC (Microchip)
- …

Microcontroller, ex. HC12 Architecture

- Processor CPU12
- 32 Kbytes Flash EEPROM
- 1 Kbytes RAM
- 768 bytes EEPROM
- PORTAD A/D 8 channels 10 bits
- PORTT Timer
- PORTS Serial SCI, SPI, 2 I/O
- PORTP 4 PWM, 4 I/O
- PORTCAN CANBUS, 5 I/O
- PORTA Address/Data
- PORTB Address/Data
- PORTE Control
- BDI Debug



Models

- In each of those families it exists a lot of different models :
  - Size in memories (RAM, ROM, EPROM, Flash,…)
  - Kind of programmable interfaces
  - Power consumption (µW..W)
  - Working frequencies (MHz..GHz)
  - Type of packages (DIL, SOP, TSSOP, BGA, µBGA,..)
  - Number of pins (6..hundred)
  - …

Memories Models

- 2 mains memory models :
  - µC can have **von Neumann** memory model, a unified memory scheme for Program /Data and stack memories
  - µC can have separate physical areas for program/data and stack, sometimes with different bus width (ex. PIC), **Harvard Architecture**

Programmable Interfaces Access

- Depending on the processor family, the access to the programmable interface part is done :
  - Memory Mapped I/O (ex. 68HC12)
  - Through specialized instructions (ex. IN/OUT)
  - Special area pages (ex. 8051 SFR space)
  - Through specific Pointer/data registers couple (ex. 8051 DPTR register)

Resume

- General Architecture
- Memories Models
- Programmable Interfaces Access
- Types of Programmable Interfaces

Operating Systems

- Linux, uLinux
- uC/OSII or uC/OSIII
- Android
- eCOS
- uKOS
- RTEMS
- etc…
- Real Time or NOT !?