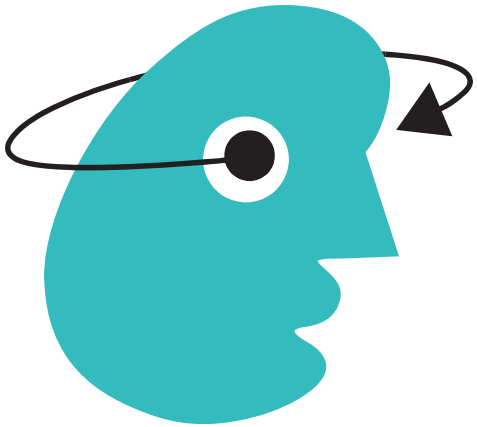

DAVe

Simply Embedded

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Milestones

- 1998: DAVE's foundation
- 2001: First Embedded CPU Module
- 2004: DAVE's became a real embedded company
- 2007: First relevant turn-key system
- 2008: First Embedded World participation
- 2009: Begin of an important with TI
- 2010: New Headquarter
- 2011: Three important Turn Key contracts
- 2012: ISO9001 certification (wikimedia as document management software)

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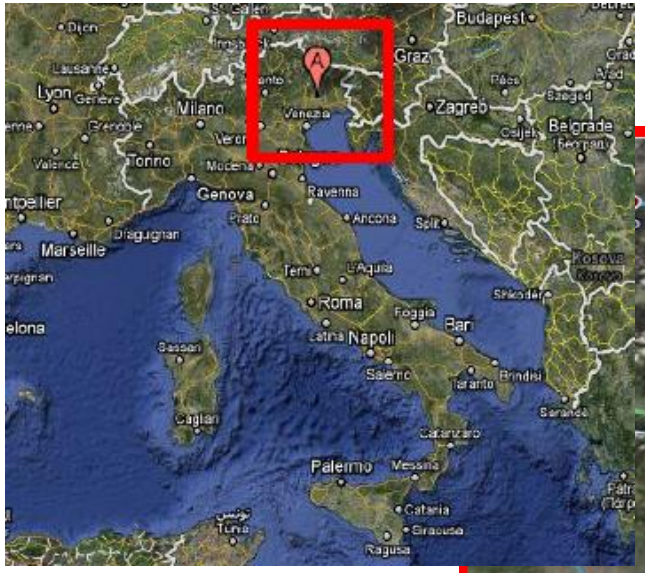
Location



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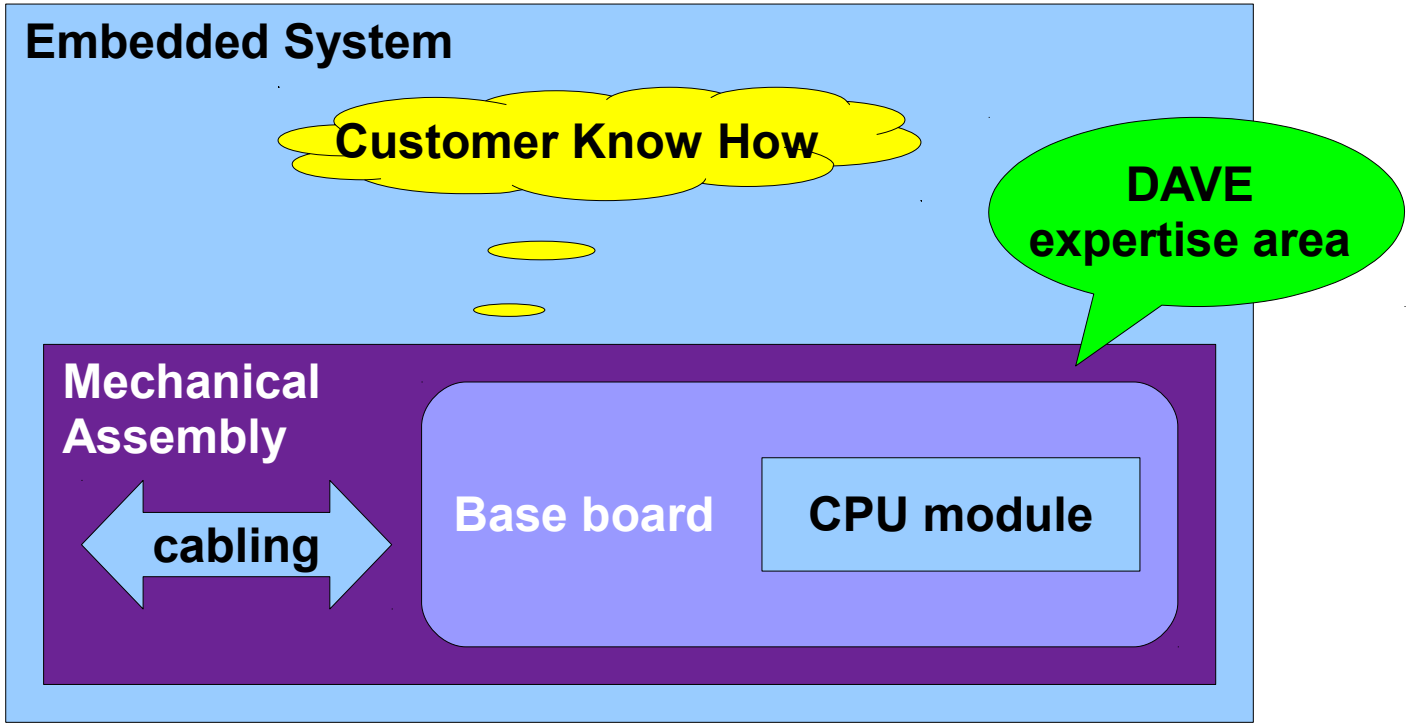
Mission

DAVE was born with the specific purpose to provide a competent, advanced and global design service in the field of embedded systems



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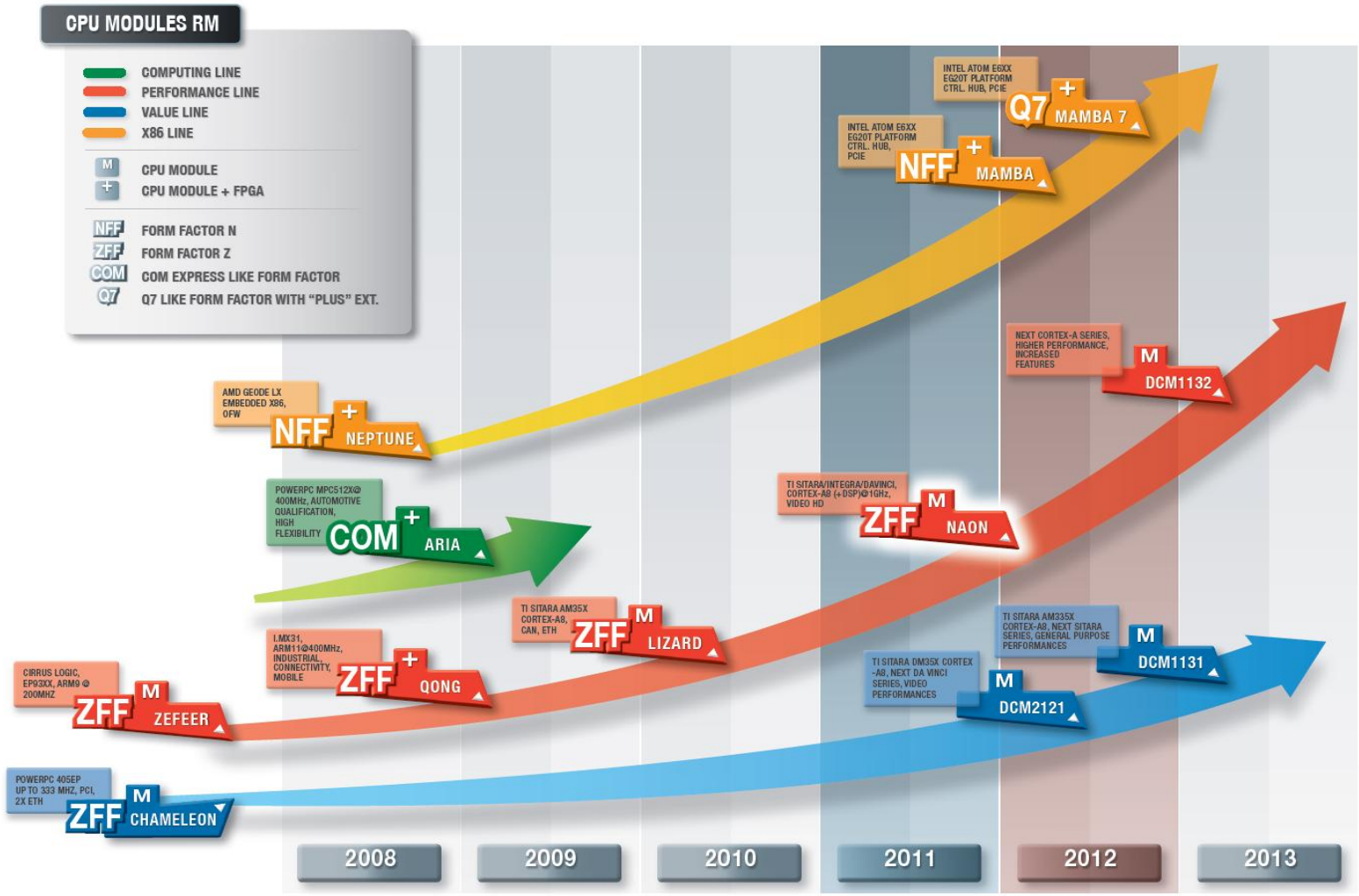
Vision



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Results

- **More than 36000 board/year**
- **Wide field of application:**

Surveillance	Automation
Entertainment	Railways
Digital Signage	Medical
Building automation	Lighting
Transportation	Dashboards

- **Around 20 employees in 2011**

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Process

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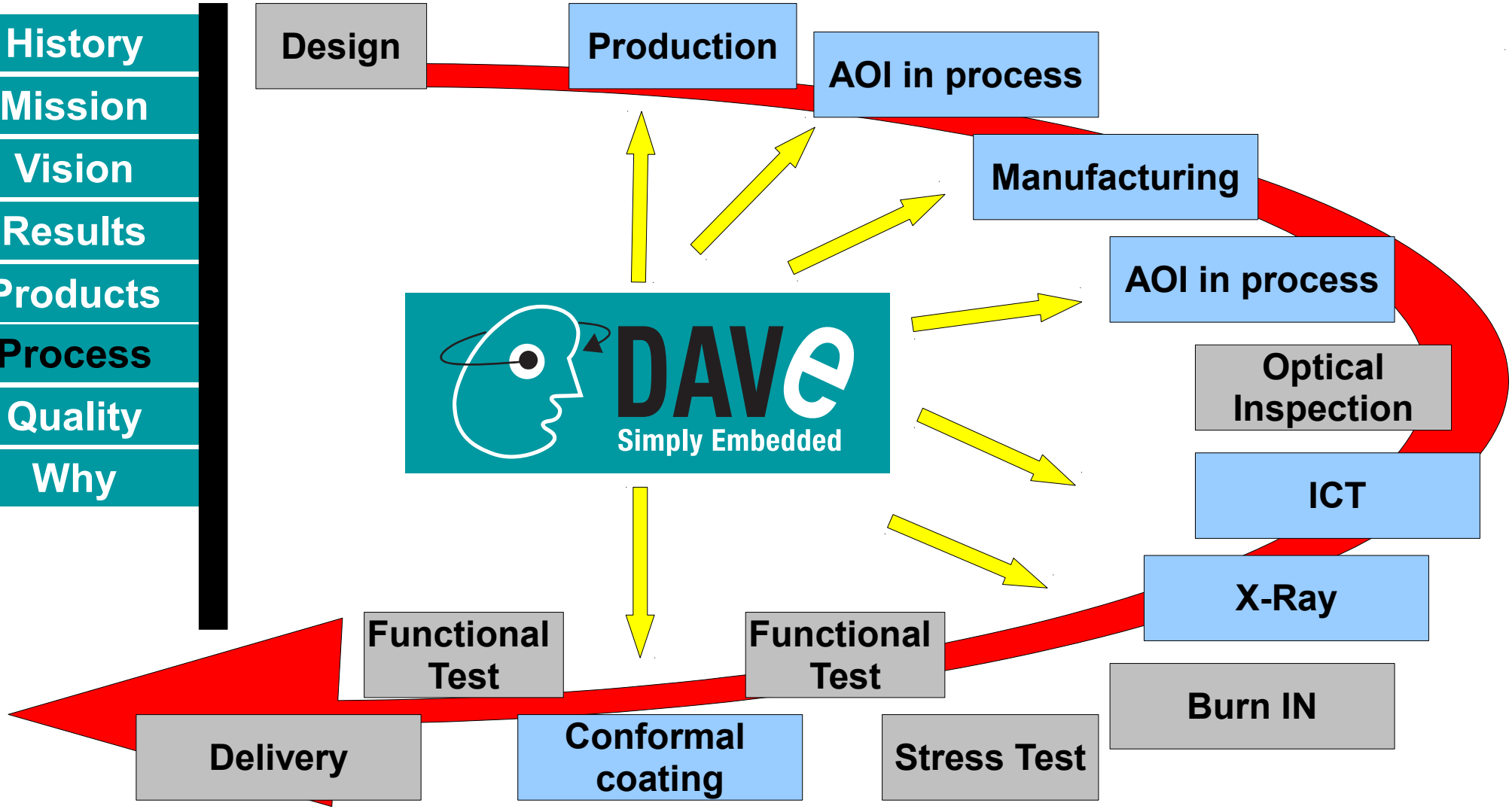
- History
- Mission
- Vision
- Results
- Products
- Process
- Quality
- Why



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Quality

- ISO9001: February 2012
- Complete traceability of production process
- Industrial application design oriented
- Internal thermal stress debug
- Internal EMC debug
- MTBF calculation

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Why: 10 Good Reasons

DAVE Simply Embedded

- History
- Mission
- Vision
- Results
- Products
- Process
- Quality
- Why

DAVE conceive, designs and manufactures all electronics distributed and sold with a **long experience** in embedded systems (more than 100 my)	Whole productive process is performed under **direct control** of DAVE, along with highest european productive standards, in the surroundings of DAVE Headquarters	Usage of pre-built, stable and complete Core Boards allows to **shorten time-to-market** approach. No more investments in R&D, No more silicon procurement, No stock costs, No obsolescence problems No tech problems, Payment after sales	**Host boards only** have to be designed on customer's request. HB are customers' added value and usually are made with different (more simple?) technology with respect to modules. Plenty of **Application Notes** are available for customers, explaining how to design their own host boards, and many ad-hoc **hints** are provided during co-design with customers.	**Design best practices** are implemented to the outmost, with a particular care with respect to safety, security, certifications, component stress, thermal dissipation. High process yield, exhaustive test, and high MTBF characterize Core Boards.
Obsessive reliability tests are performed on modules. Start-stop cycles, extreme temperatures validations, MTD reliability, MTBF calculations, are some of the validation and production sampling tests that are preformed on modules.	**Long-life delivery program** is provided for DAVE product line. CPU are mainly (possibily) chosen among the automotive set. Although not standardized, modules are pincompatible for same product family.	**Outstanding support:** host board co-design host-board review host-board bring-up frequent software upgrade customer follow up	**DAVE's support includes** – but is not limited to - **mere electronics**. A high perchentage of DAVE's turnover is made up with complete electronic systems, therefore DAVE's expertise may be precious also with respect to system aspect, software applications, mechanichs.	DAVE yields **several commercial plus**: commercial guarantees for production discontinuities, stability of prices, wide stock buffers, disclosure of designs in case of production stops, ...

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Introduzione ai sistemi embedded

Molte definizioni in letteratura; nessuna universalmente riconosciuta. Wikipedia propone:

> Con il termine sistema embedded (sistema incapsulato, dedicato) si identificano genericamente dei **sistemi elettronici a microprocessore** progettati appositamente per **una determinata applicazione**, spesso con **una piattaforma hardware ad hoc**, integrati nel sistema che controllano e in grado di gestirne tutte o parte delle funzionalità.

Alcune differenze rispetto ad un sistema PC classico:

- Frequenze di lavoro (potenza di calcolo) tipicamente inferiori (...)
- Tagli di memoria inferiori (...)
- Dispositivi di I/O spesso piu' limitati o addirittura assenti
- Molte architetture non x86 (ARM, PowerPC, MIPS, SH-4 ecc.) profondamente incompatibili tra loro
  - Diversa endianness
  - Diverso set di istruzioni
  - Diversa organizzazione della memoria

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Classificazione (opinabile) dei processori

- General purpose: Intel/AMD x86, PowerPC, SPARC, ..
  - Software generico
  - S.O. complessi (Unix, Linux, Windows NT ecc.)
  - Applicazioni disparate (da office automation a simulazioni di sistemi biologici)

- Processori Embedded: ARM, x86 (Geode LX, Atom), SuperH, MIPS, PowerPC
  - S.O. compatto ridotto, spesso real-time
  - Supporto funzionalita' DSP
  - Applicazioni mirate: telefonia cellulare, elettronica di consumo, controllo industriale
  - Nuovo trend: i processori embedded stanno conquistando mercati che fino a poco tempo fa erano impensabili come il mondo dei server

- Microcontrollori
  - Il costo ridotto e' l'obiettivo fondamentale
  - Parallelismo ridotto (tipicamente 8 bit)
  - Volumi di produzione enormi
  - Applicazioni: automobili, termostati, telecomandi ecc.

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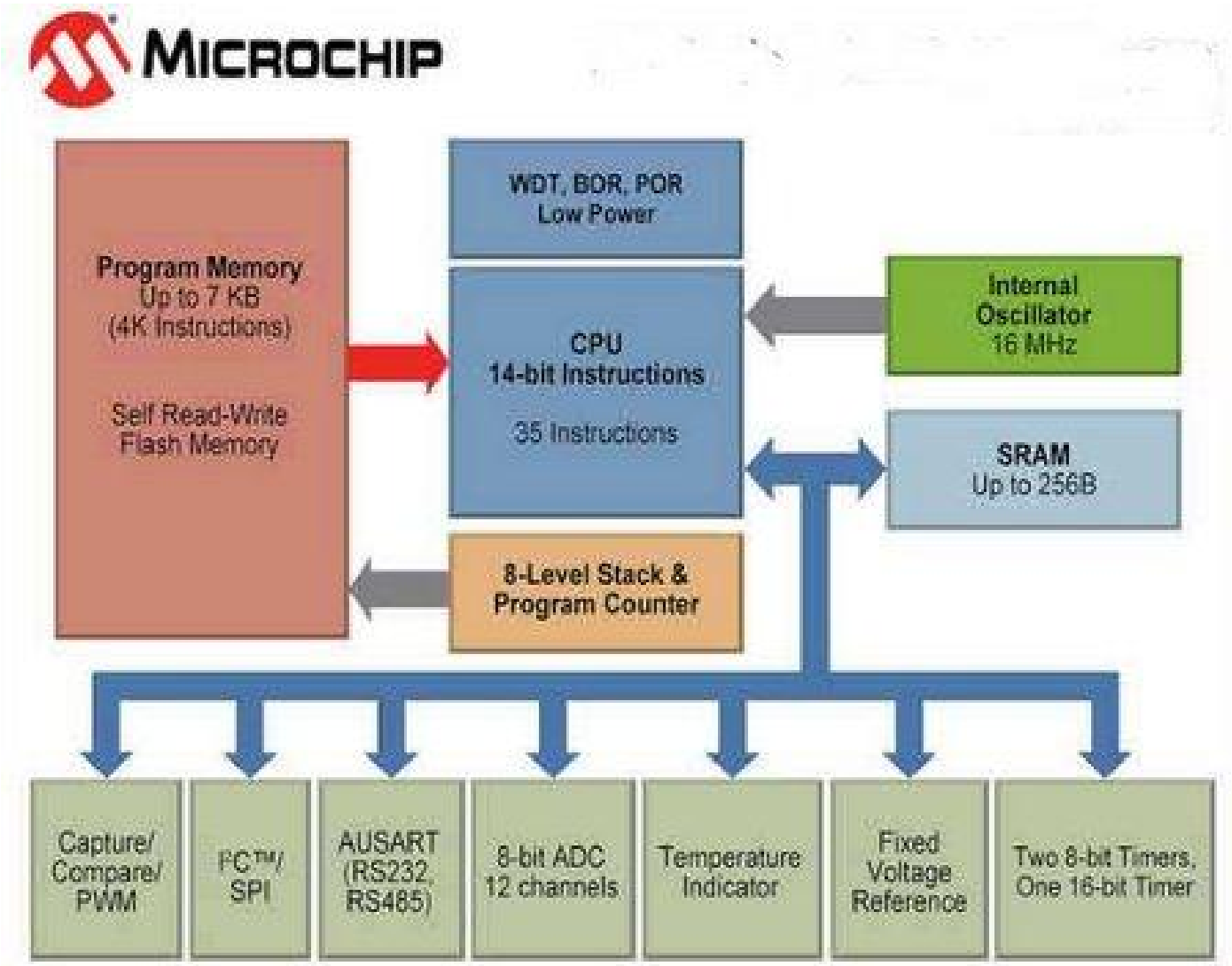
Microcontrollore



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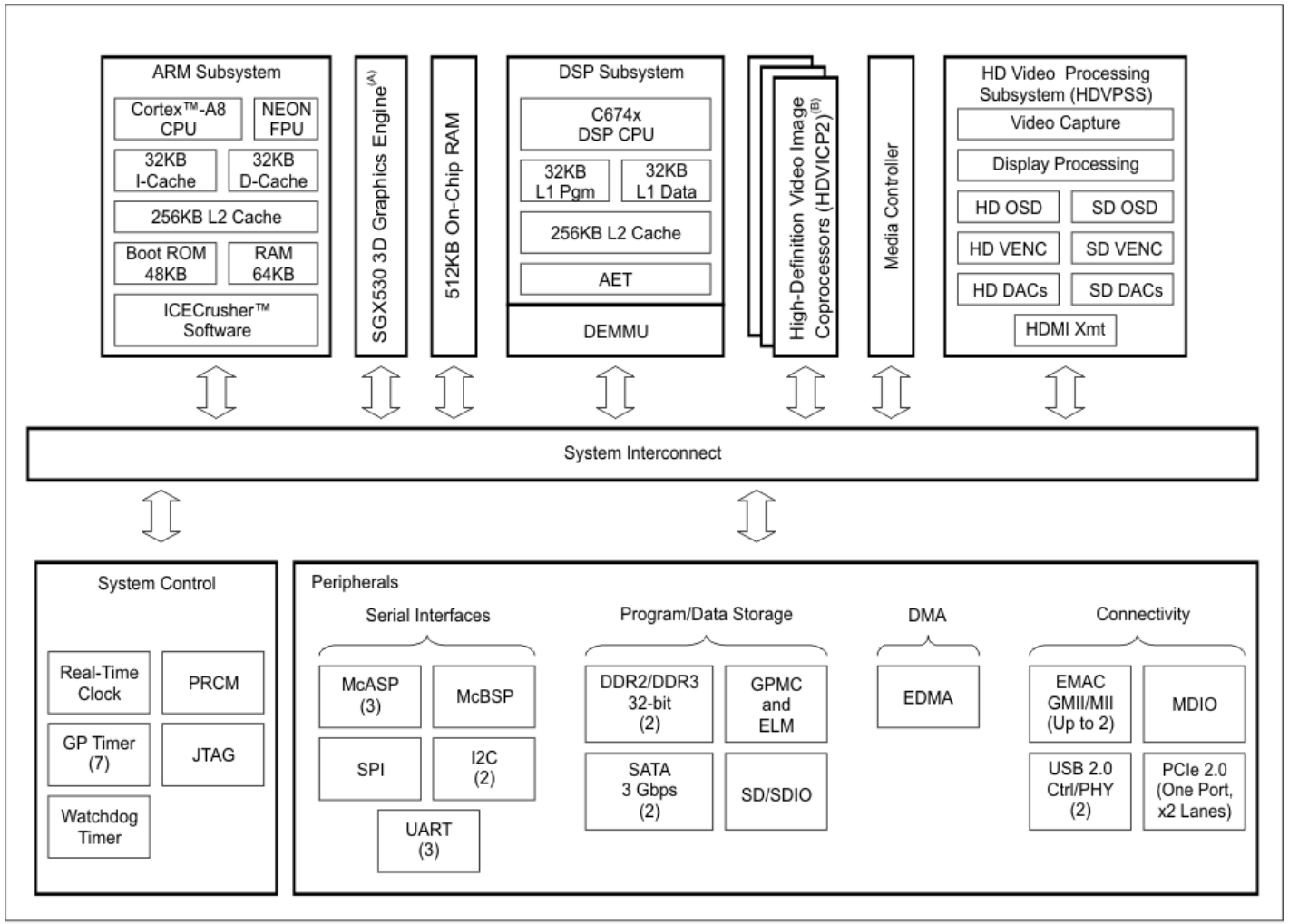
Embedded processor



A. SGX530 is available only on the TMS320DM8168 and TMS320DM8166 devices.
B. Three HD Video Image Coprocessors (HDVICP2) are available on the TMS320DM8168 and TMS320DM8167 devices; two are available on the TMS320DM8166 and TMS320DM8165 devices.

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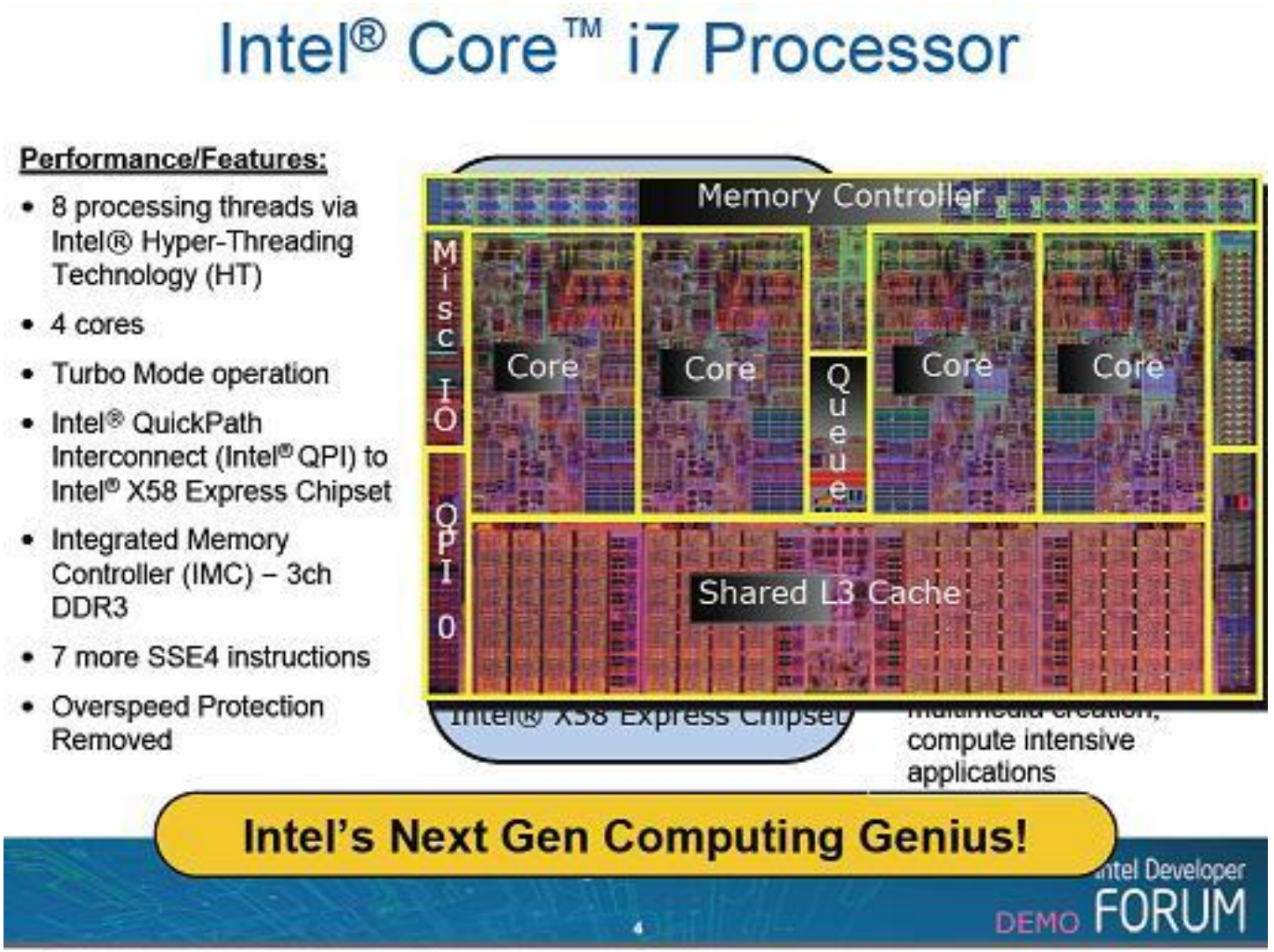

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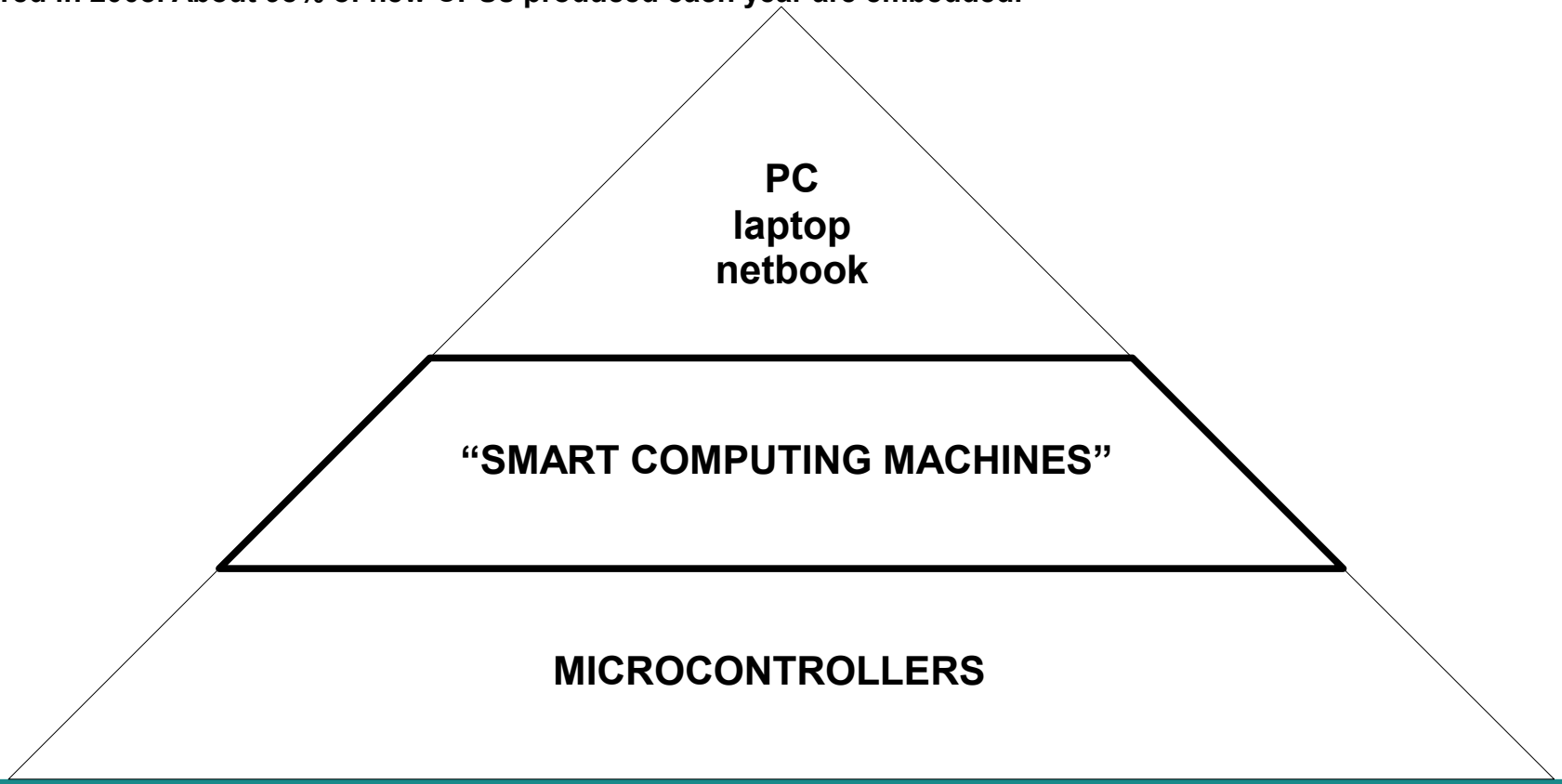
Performances/prices/volumes pyramid

Market statistics (source: wikipedia)
In 2003, about $44 billion (USD) worth of microprocessors were manufactured and sold.[35] Although about half of that money was spent on CPUs used in desktop or laptop personal computers, those count for only about 2% of all CPUs sold. About 55% of all CPUs sold in the world are 8-bit microcontrollers, over two billion of which were sold in 1997. As of 2002, less than 10% of all the CPUs sold in the world are 32-bit or more. Of all the 32-bit CPUs sold, about 2% are used in desktop or laptop personal computers. Most microprocessors are used in embedded control applications such as household appliances, automobiles, and computer peripherals. Taken as a whole, the average price for a microprocessor, microcontroller, or DSP is just over $6. About ten billion CPUs were manufactured in 2008. About 98% of new CPUs produced each year are embedded.



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Esempi di sistemi embedded

- Sportelli Bancomat e apparecchi POS
- Telefoni cellulari/PDA/tablet
- Sistemi di telecomunicazioni, apparati di networking
- Sistemi di automazione casalinghi come termostati, condizionatori, allarmi, ...
- Sistemi di monitoraggio ambientale
- Sistemi HVAC (Heating, Ventilation and Air Conditioning)
- Sistemi HACCP (Hazard Analysys and Critical Control Points)
- Distributori di bevande
- Apparecchiature medicali
- Centraline di controllo per automotive
- Media player/console portatili e non
- Digital set top box
- Sistema frenatura veicoli
- ...

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Target semplici, sfide impegnative...

- Progettare un sistema che abbia le risorse minime e indispensabili (processore, PSU, memorie) da consentire:
  - …che il sistema parta perfettamente il 100% delle volte…
  - …nel più breve tempo possibile….
  - …garantendo la continuità del servizio...
  - …con bassi consumi.
- Il sistema, se interrotto per qualche motivo, deve ripartire in qualsiasi condizione
- Il sistema deve essere gestito da un sistema operativo (talvolta real time)
- Gli ingombri devono essere ridotti
- I consumi devono rispettare determinati limiti
- I costi di produzione devono essere più bassi possibile
- Il sistema deve lavorare nel range di temperatura esteso (-40/+85°C)
- Il sw di sistema deve poter essere aggiornato
- Conformita' a normative (EMC)
- ...

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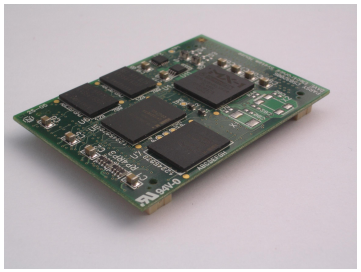
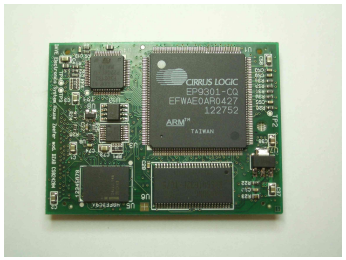
Modulo CPU (aka SOM = system-on-module)

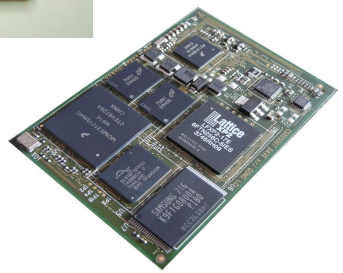
Simply Embedded

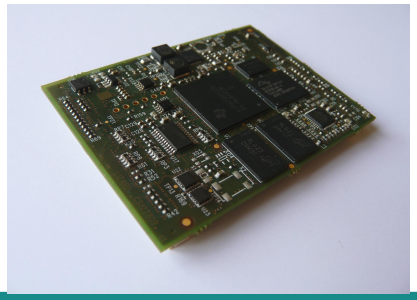
Cuore di un sistema embedded, fornisce tutte le risorse di base del sistema, consentendo a chi sviluppa il prodotto di concentrarsi esclusivamente su di esso.

Per definizione e' un oggetto intrinsecamente *general purpose.*









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SOM: examples (1/2)

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CPU Modules | CPU + FPGA | Systems

- **Zefeer**
  CPU module based on Cirrus Logic EP93xx ARM9 @ 200MHz with up to 32MB NOR Flash and 64MB RAM memory, 3 UARTs, 3USB, ETH 10/100, SPI, I2C, LCD up to 800x600, audio I2S, keypad controller 9x9

- **Lizard**
  CPU module based on Texas Instruments SITARA AM35xx ARM Cortex A8 @ 600MHz with up to 128MB NOR, 256MB RAM and 1GB NAND memory. 3 USB (2 Host, 1 OTG), 3 UARTs, ETH 10/100, I2C, SPI, RTC, LCD up to 2048x2048, cam input, CAN bus

- **Naon**
  CPU module based on Texas Instruments CPUs. It is possible to choose among SITARA AM387x, DAVINCI DM8148x and INTEGRA Cy8148. Up to 512MB RAM, 128MB NOR, 2GB NAND, SATA, 2 CAN, 2xETH 10/100/1000 switch, LCD, DSP, Video acceleration

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SOM: examples (2/2)

CPU Modules | CPU + FPGA | Systems

- **Qong**
  Based on CPU Freescale i.MX31 (ARM) @ 400MHz with up to 128MB NOR Flash, 128MB RAM and 1GB NAND Flash. FPGA on board with ETH 10/100/1000 IP. CAN, UARTS, USBs and all FPGA pins configurable

- **Aria**
  Based on CPU Freescale MPC512x (PowerPC) @ 400MHz, COM express format with third non standard connector for FPGA on board. All pins are configurable

- **Mamba/Guru**
  Based on Intel ATOM (x86) with PCIe channel for standard companion chip and another PCIe channel for FPGA connection. Neptune form factor and all pins are configurable

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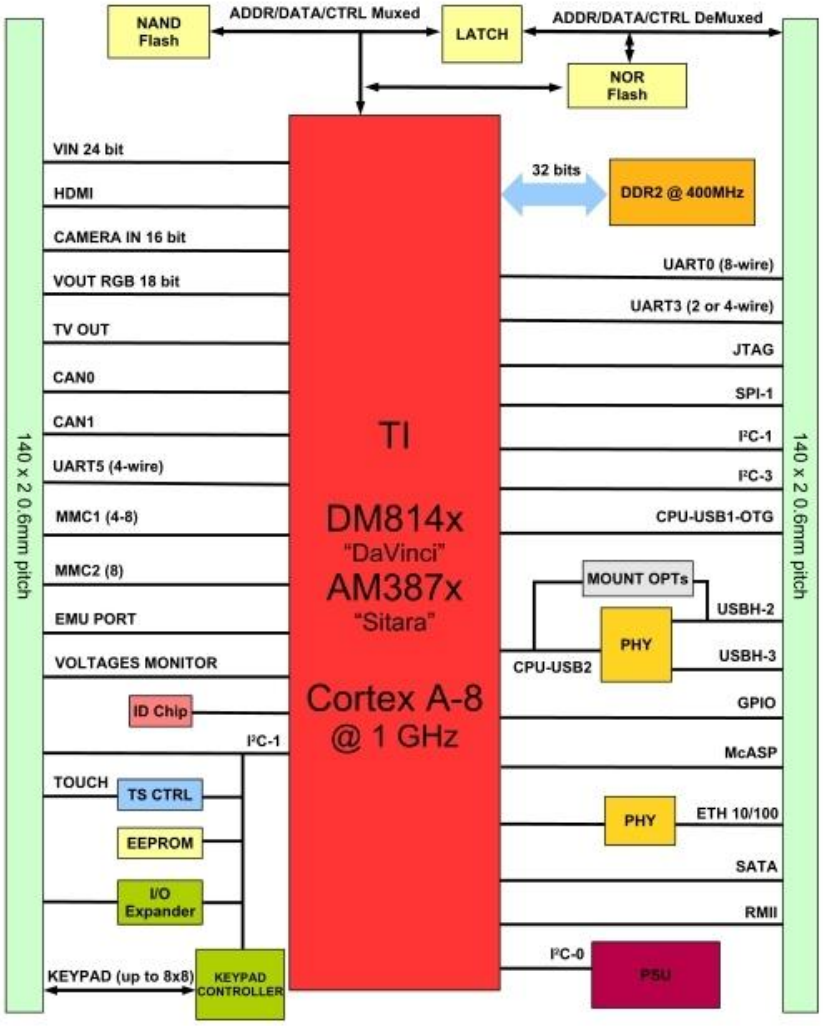
SOM: Naon



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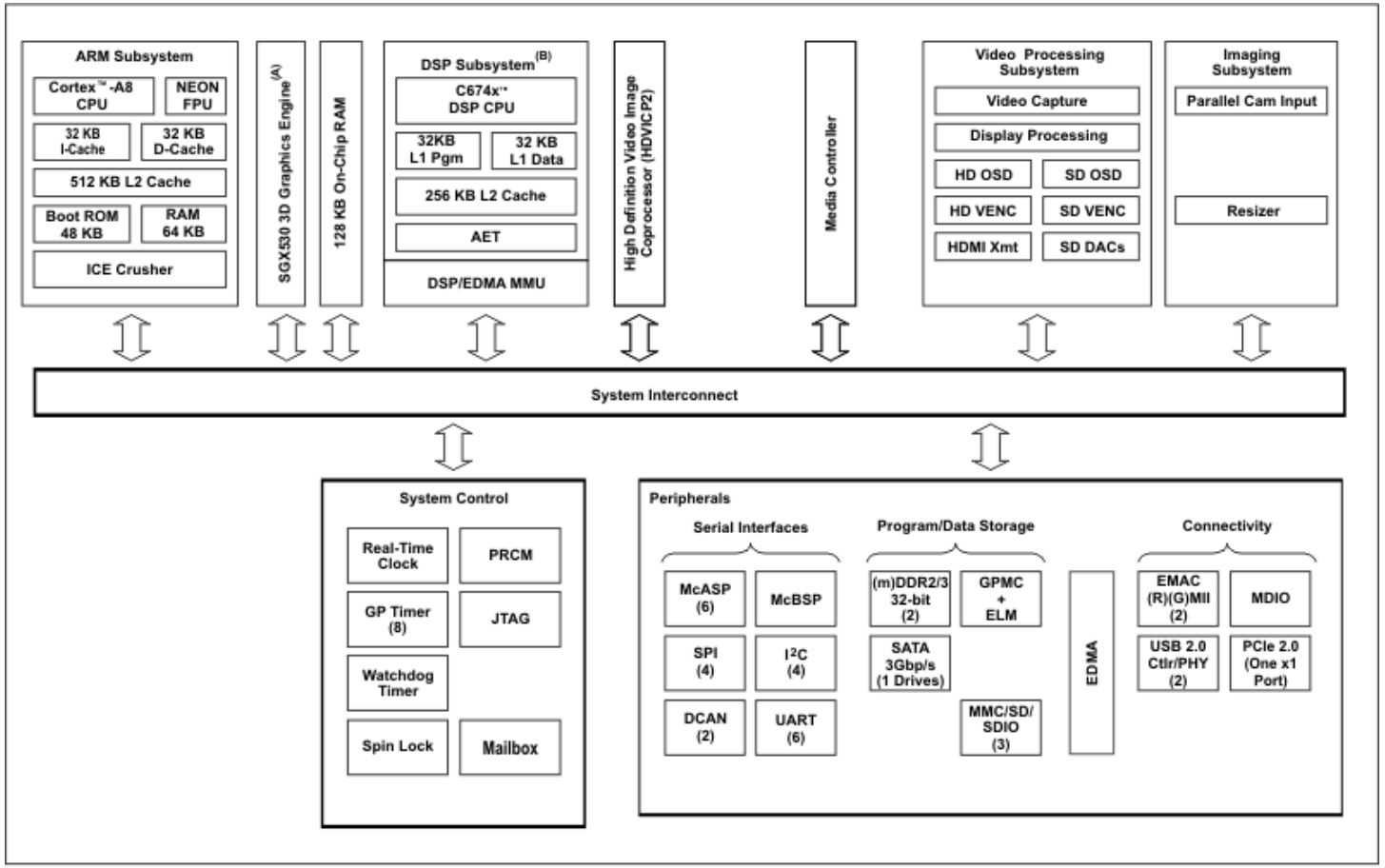
SOM: Naon

- **Basato su SOC (system-on-chip) Texas Instruments DM8148 (multiprocessore, multiarchitettura)**



A. SGX530 is only available on the DM8148 and DM8146 devices.
B. DSP Subsystem is only available on the DM8148 and DM8147 devices.

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SOM: Naon

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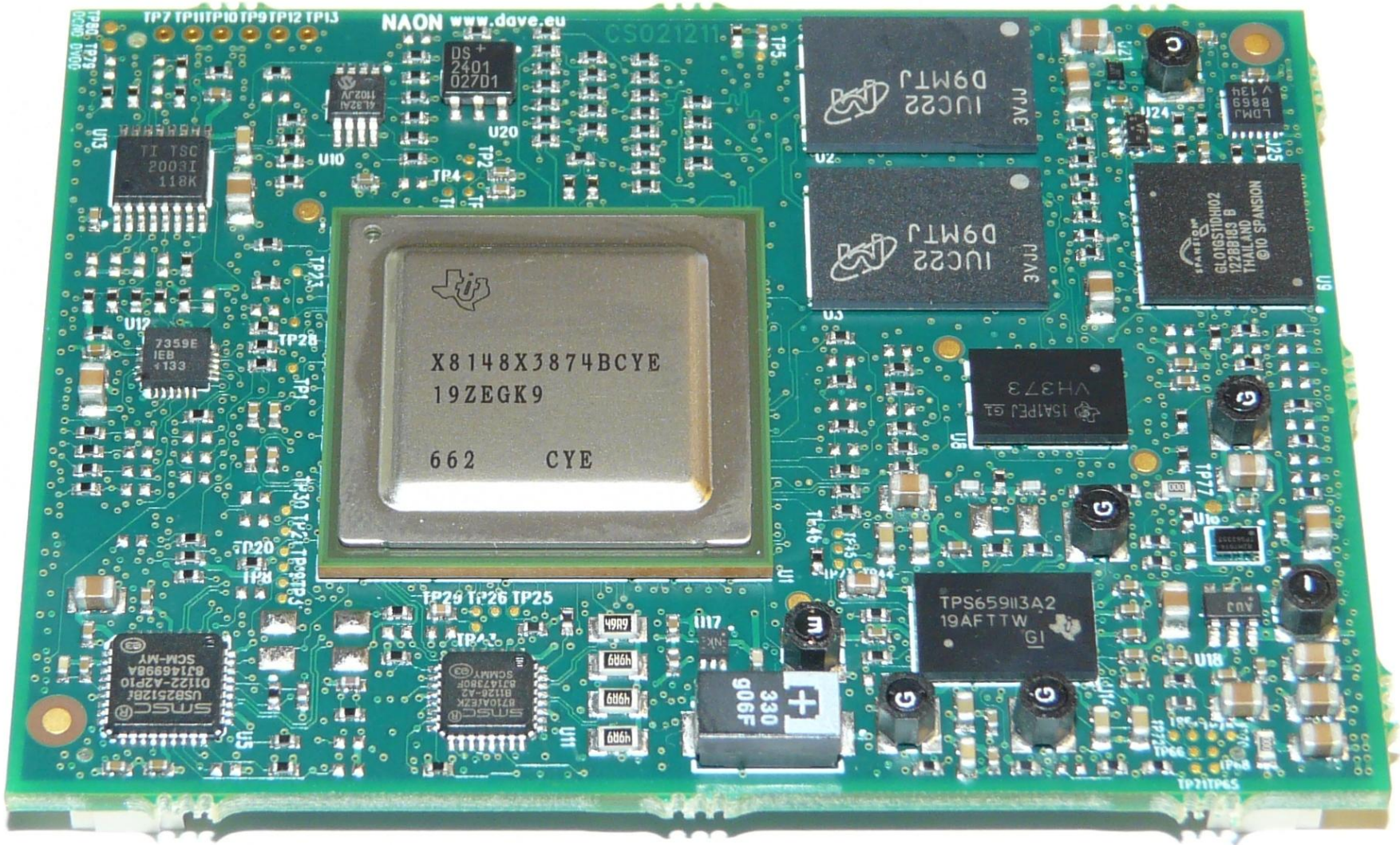

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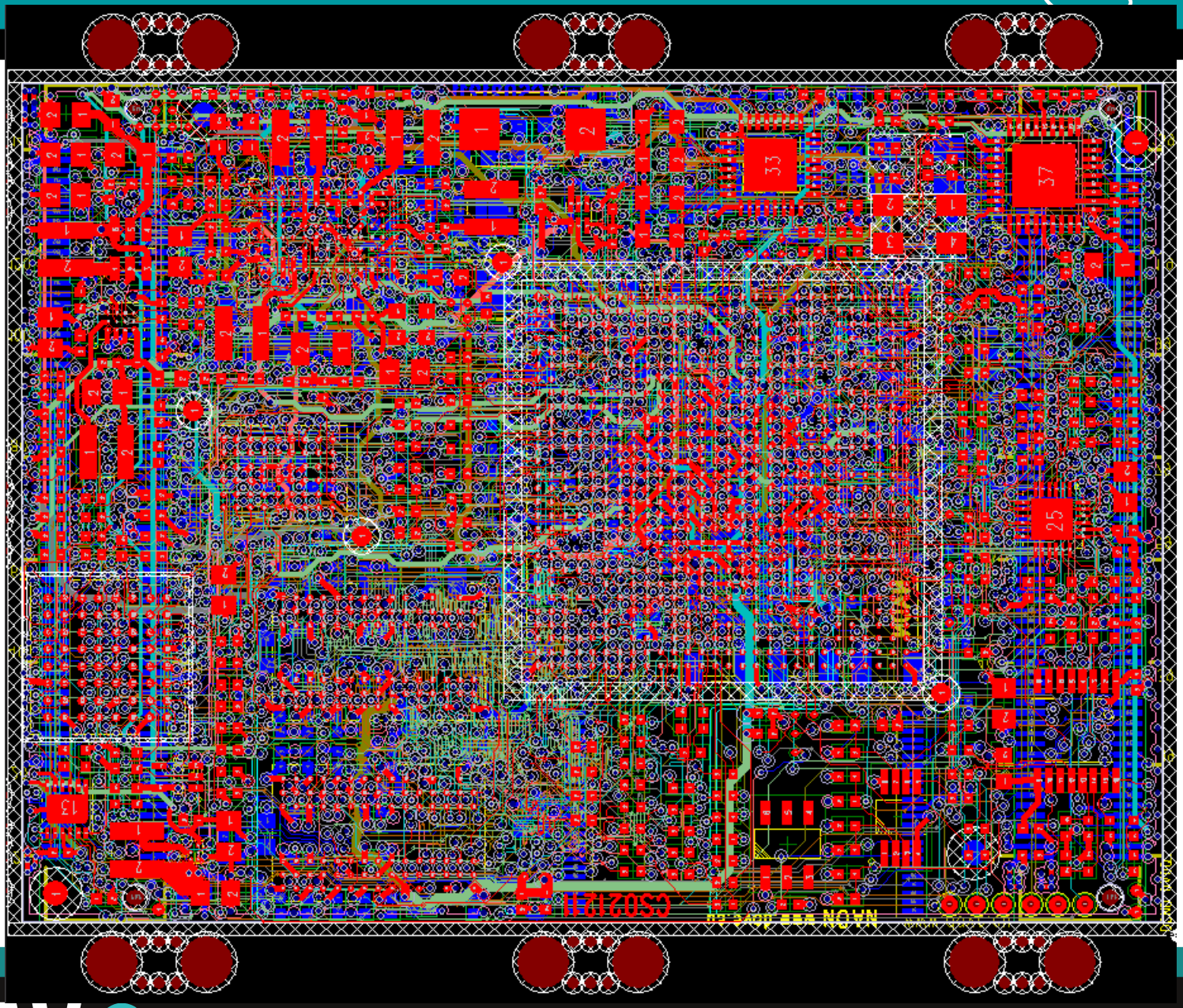

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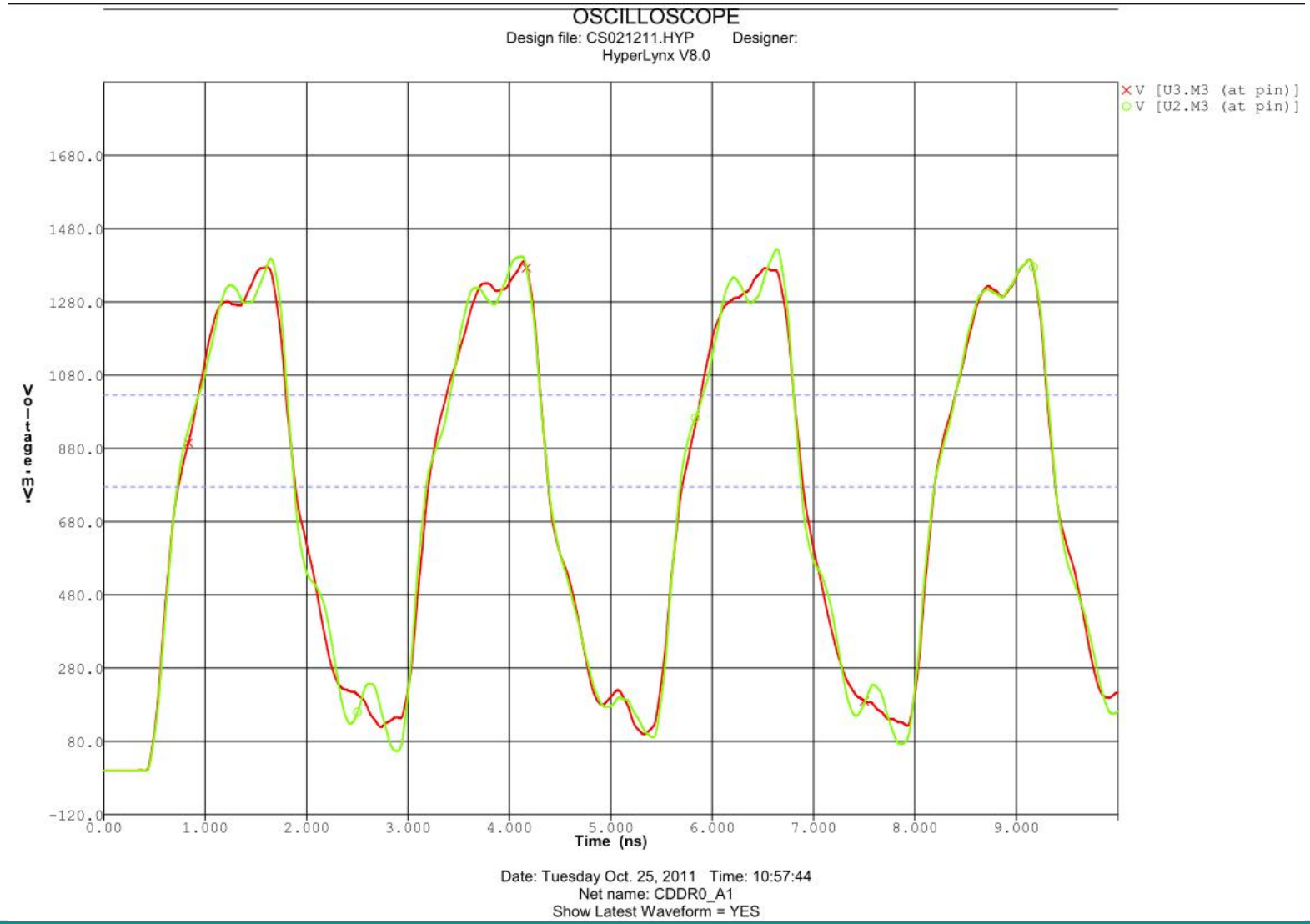

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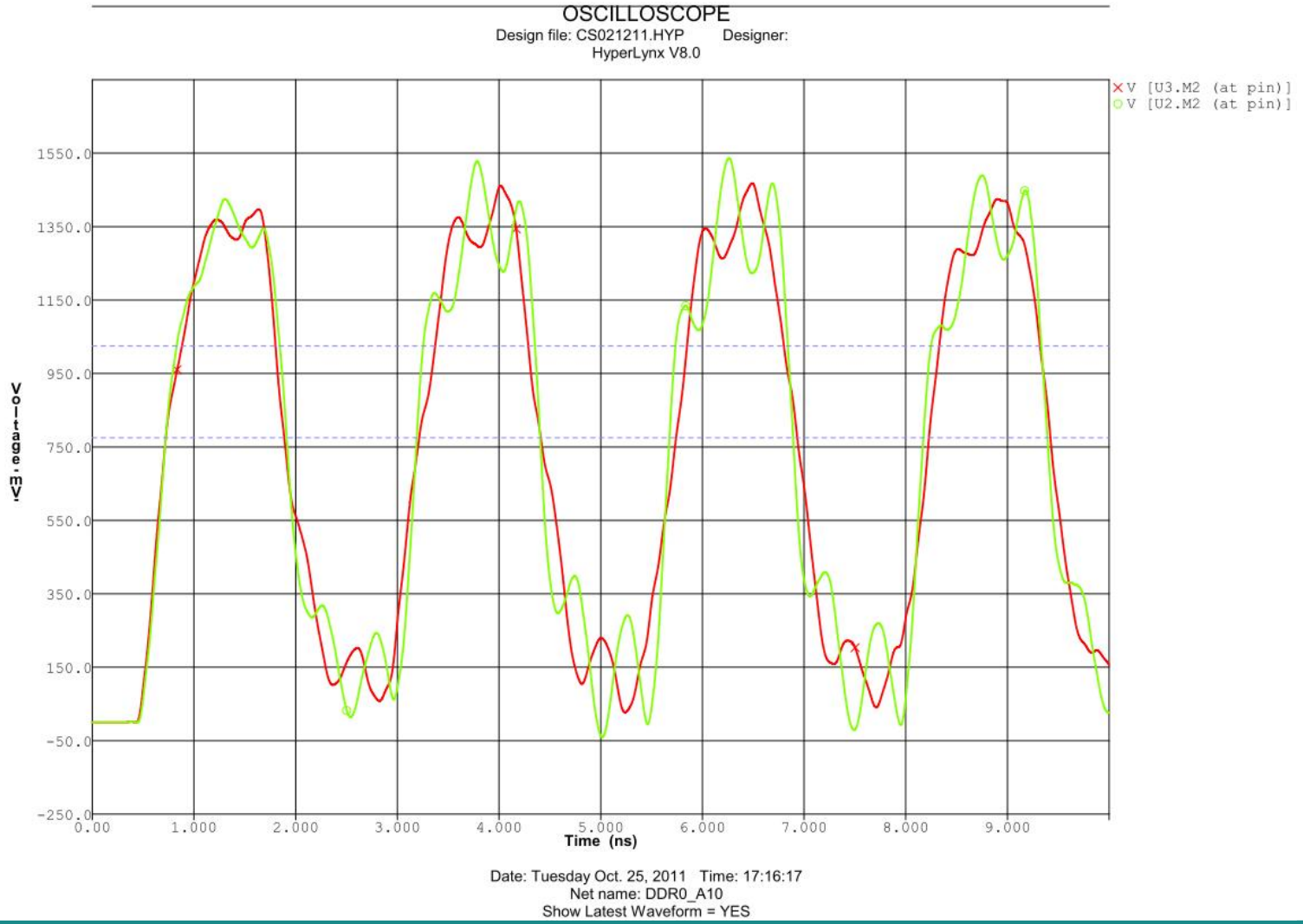

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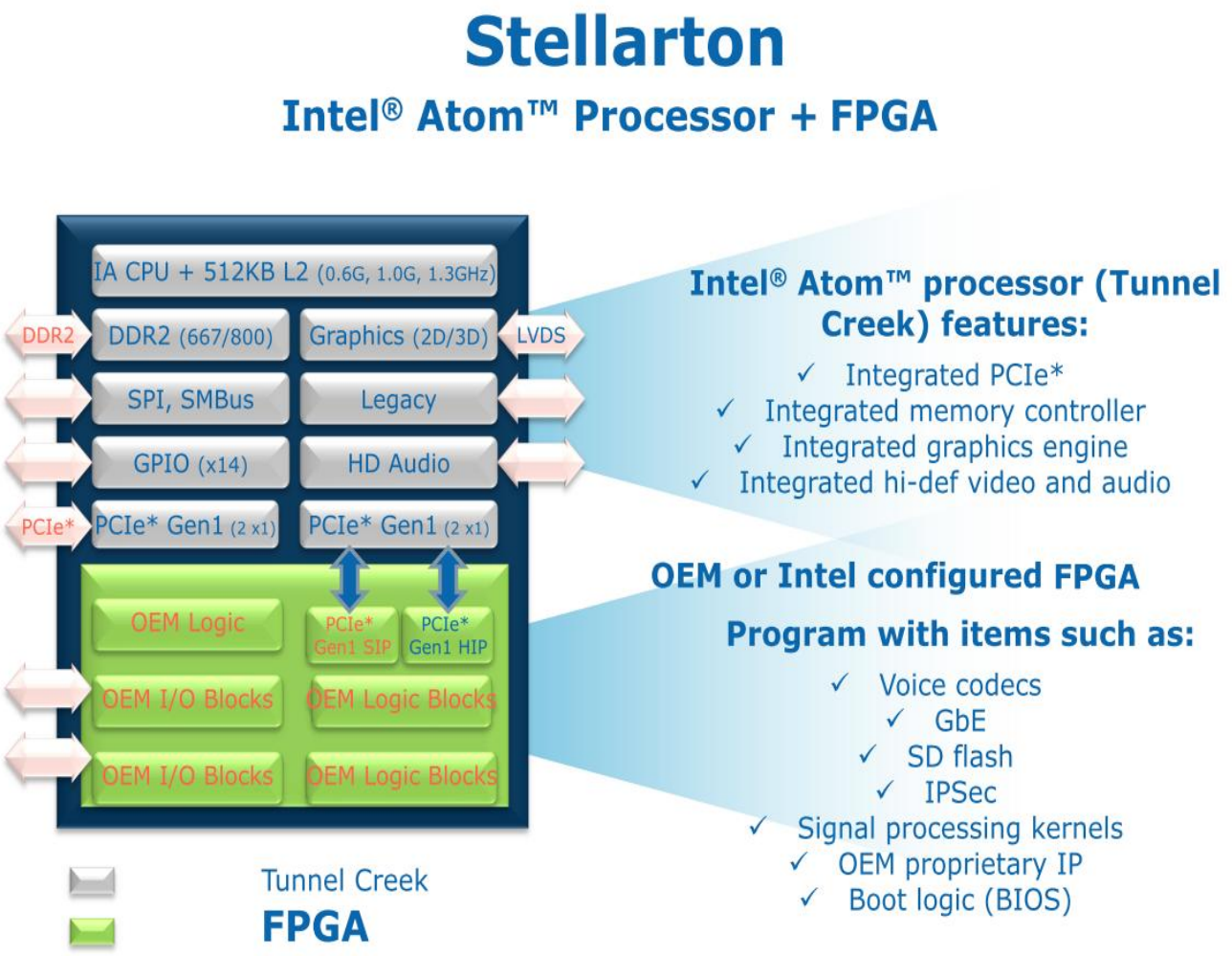
SOM: CPU + FPGA



In piu' occasioni vari costruttori hanno proposto questa soluzione che non ha mai sfondato

- Xilinx Virtex4 (PowerPC 405)
- Altera Excalibur (ARM9)
- Xilinx Zynq (ARM CortexA9)
- Intel Stellarton (Atom + Altera)

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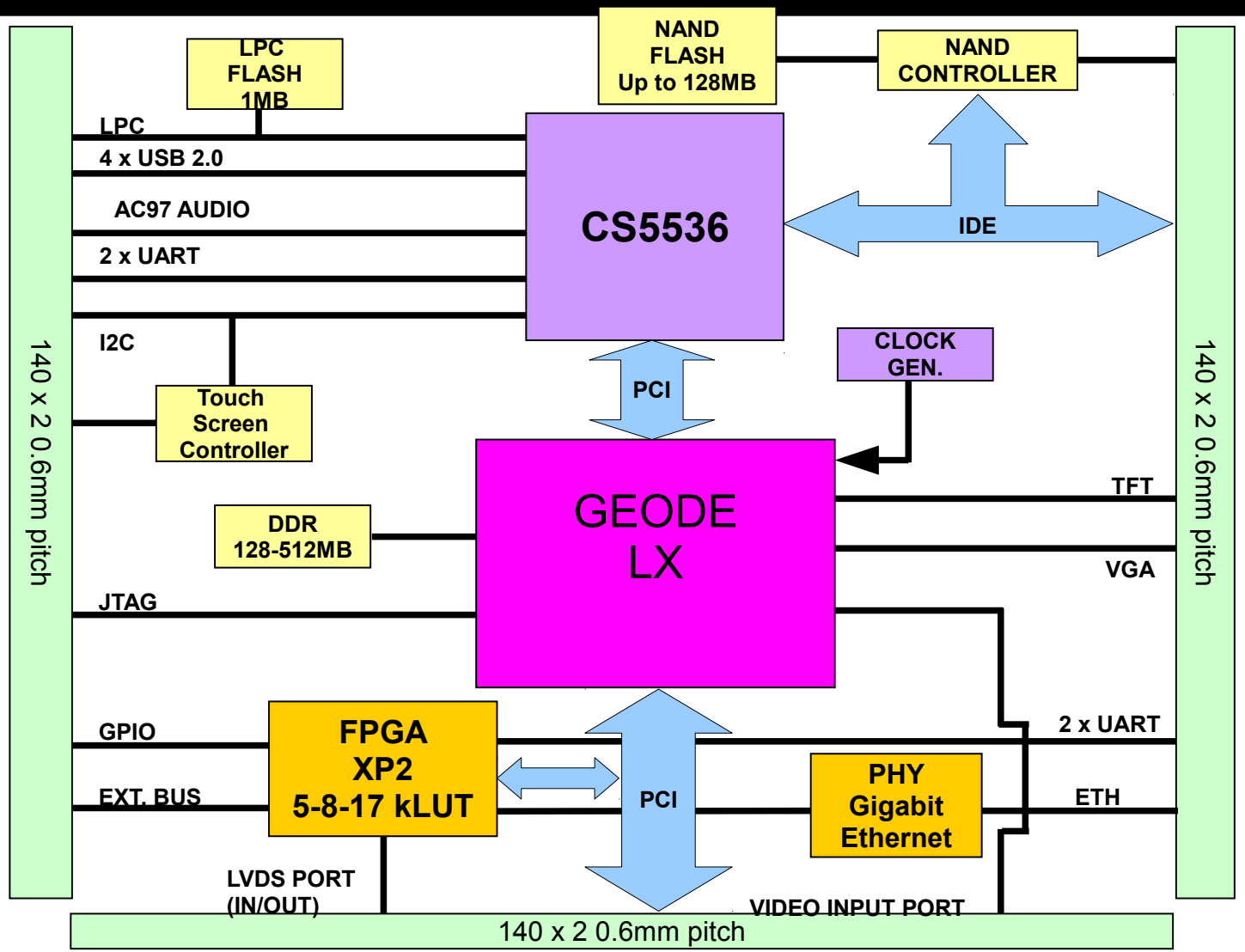
SOM con FPGA: Neptune (x86)



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SOM con FPGA: Neptune (x86)

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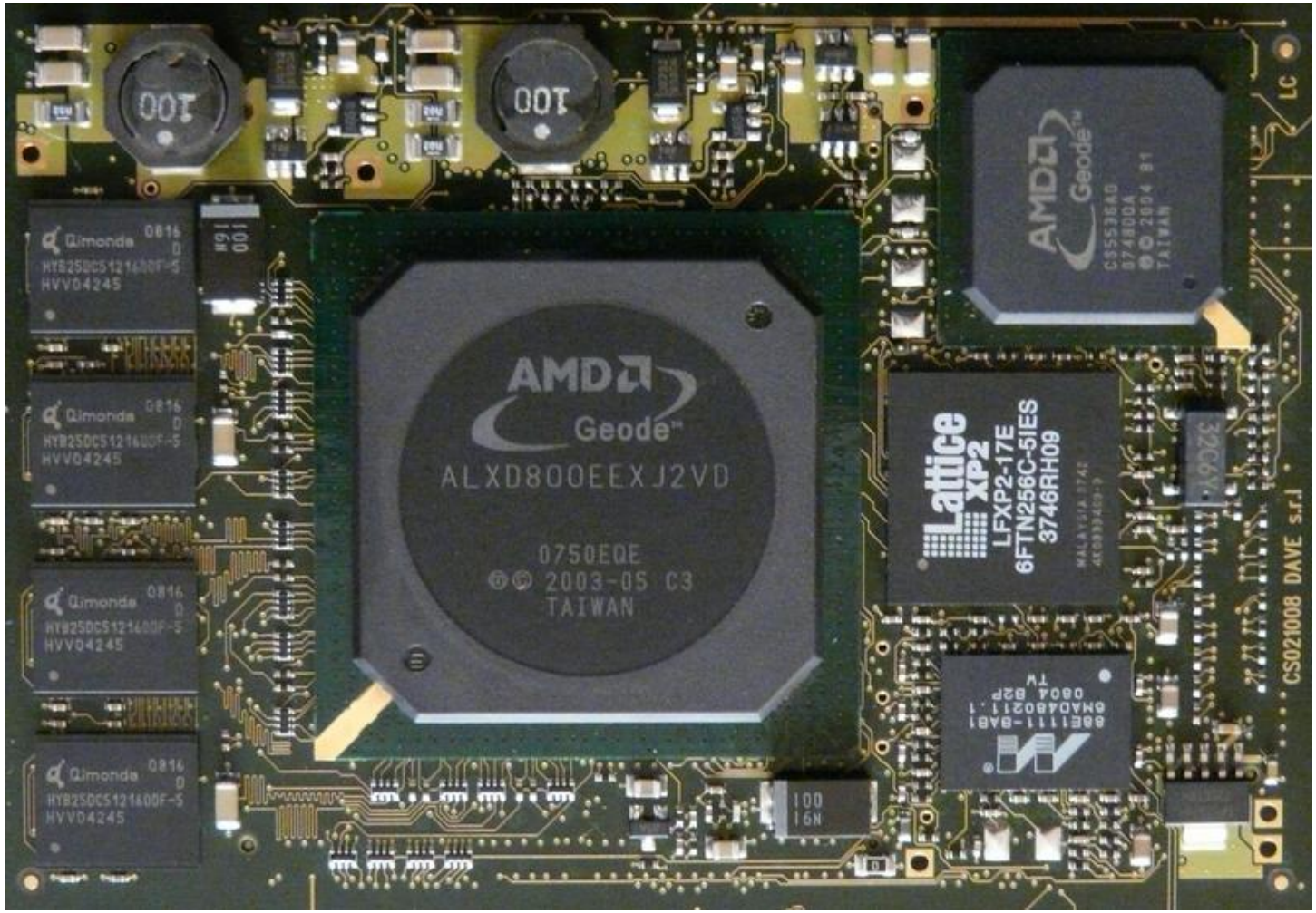
Simply Embedded



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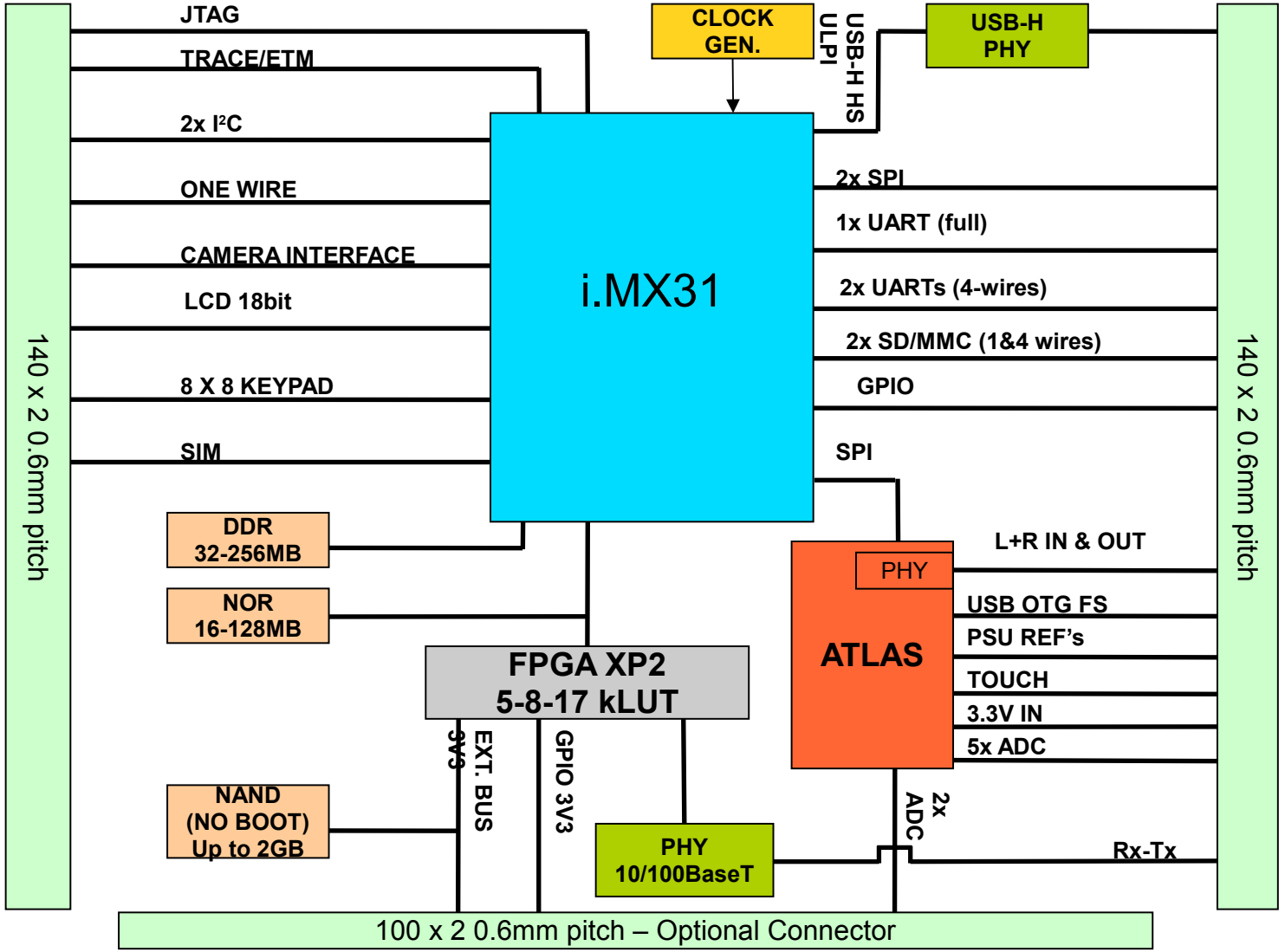
SOM con FPGA: Qong (ARM11)



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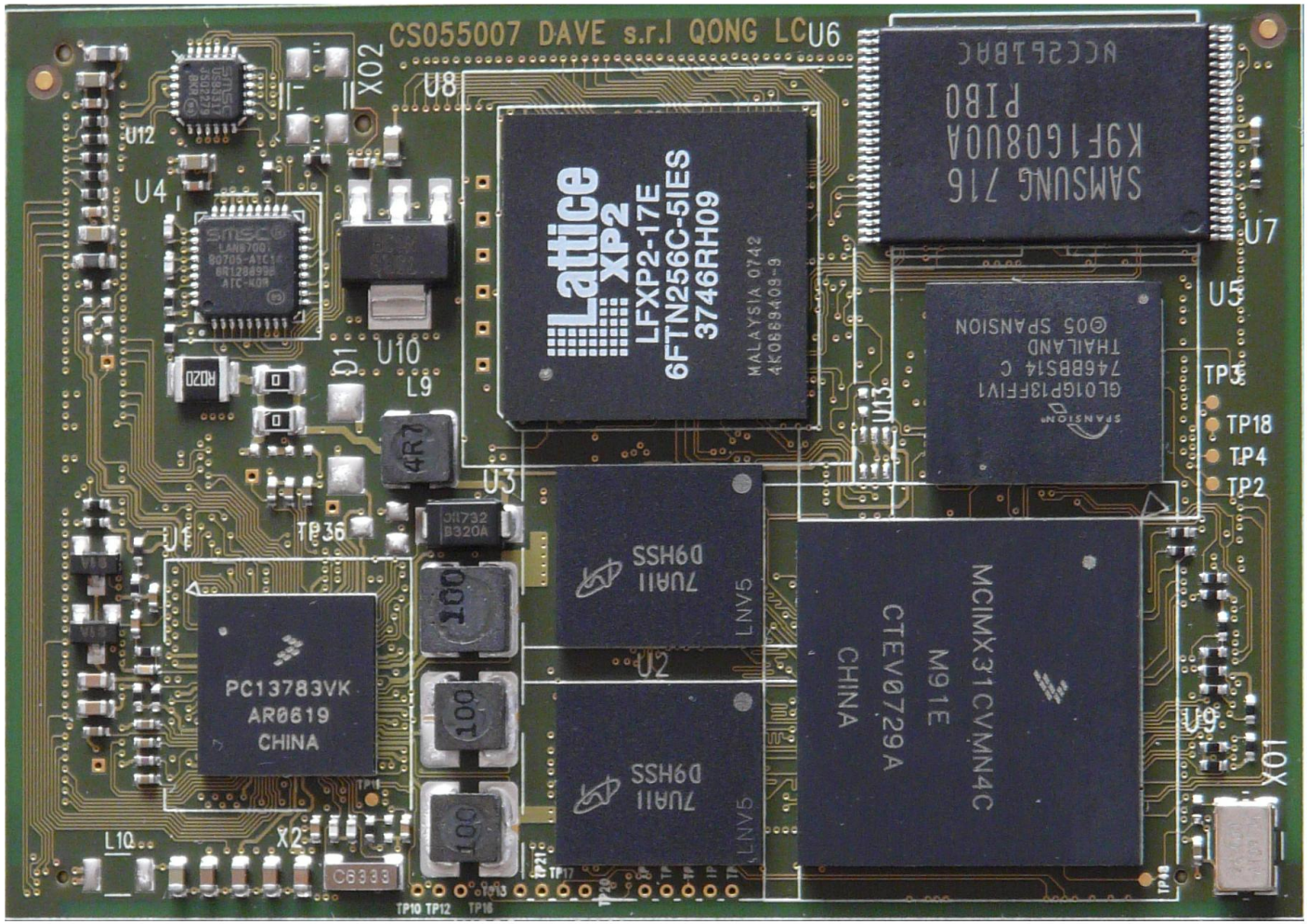
SOM con FPGA: Qong (ARM11)

DAVe
Simply Embedded



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Systems

Systems are usually built upon off-the-shelf SOM

- Transportation / Railways
- Dashboards
- Building automation
- Industrial applications
- Medical applications
- Telecommunications

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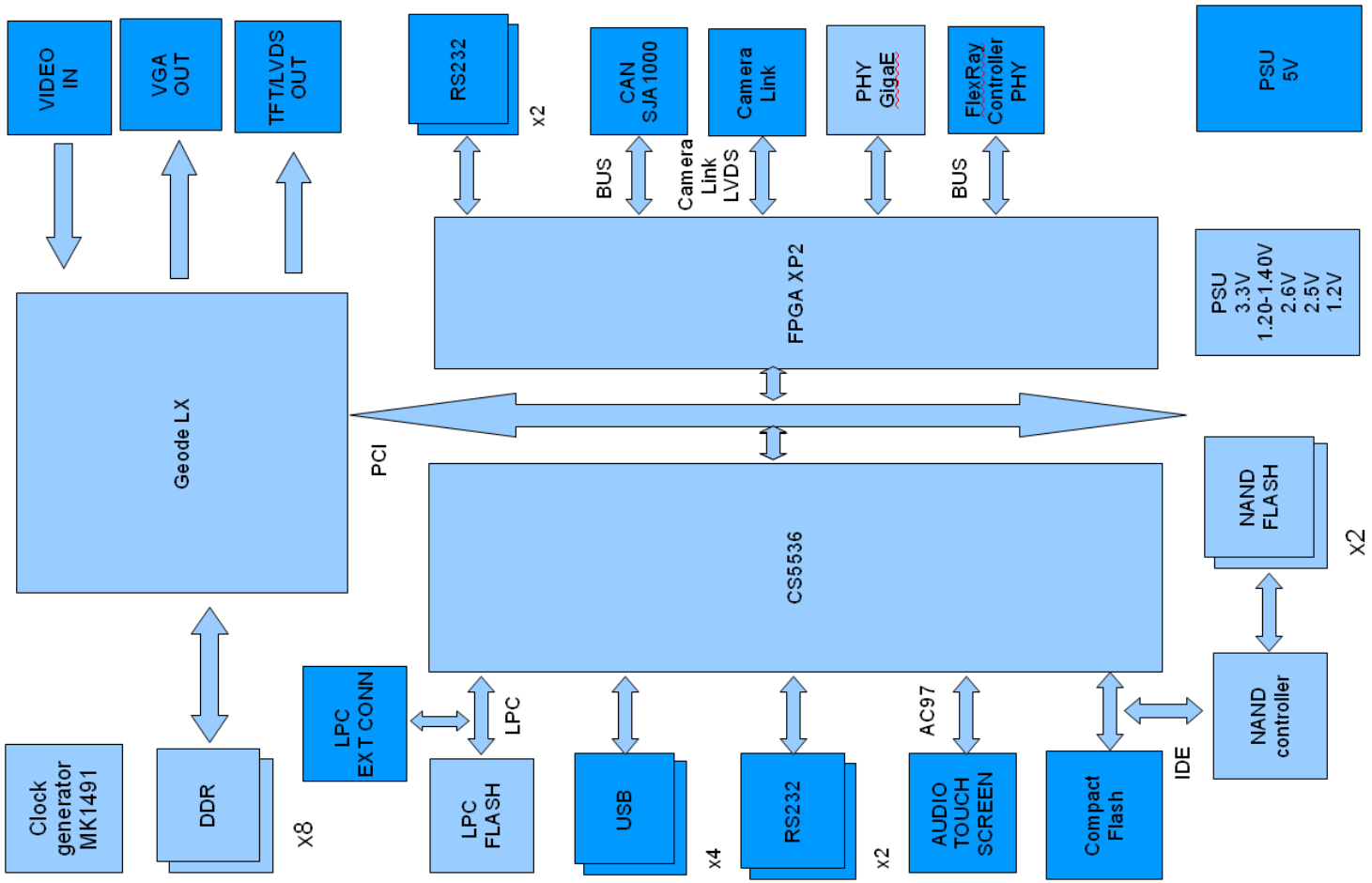
Sistema completo: 996



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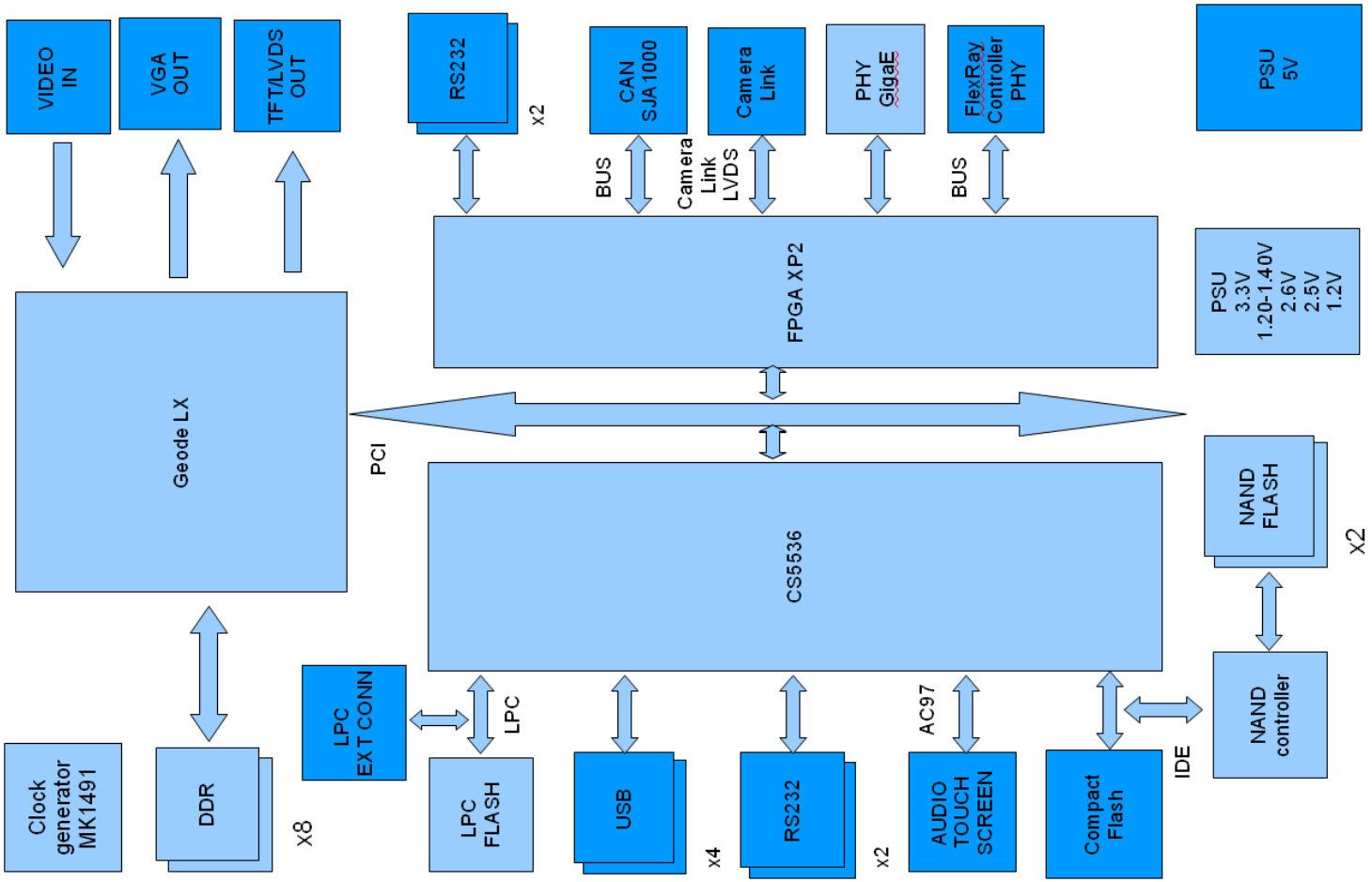
Sistema completo basato su SOM



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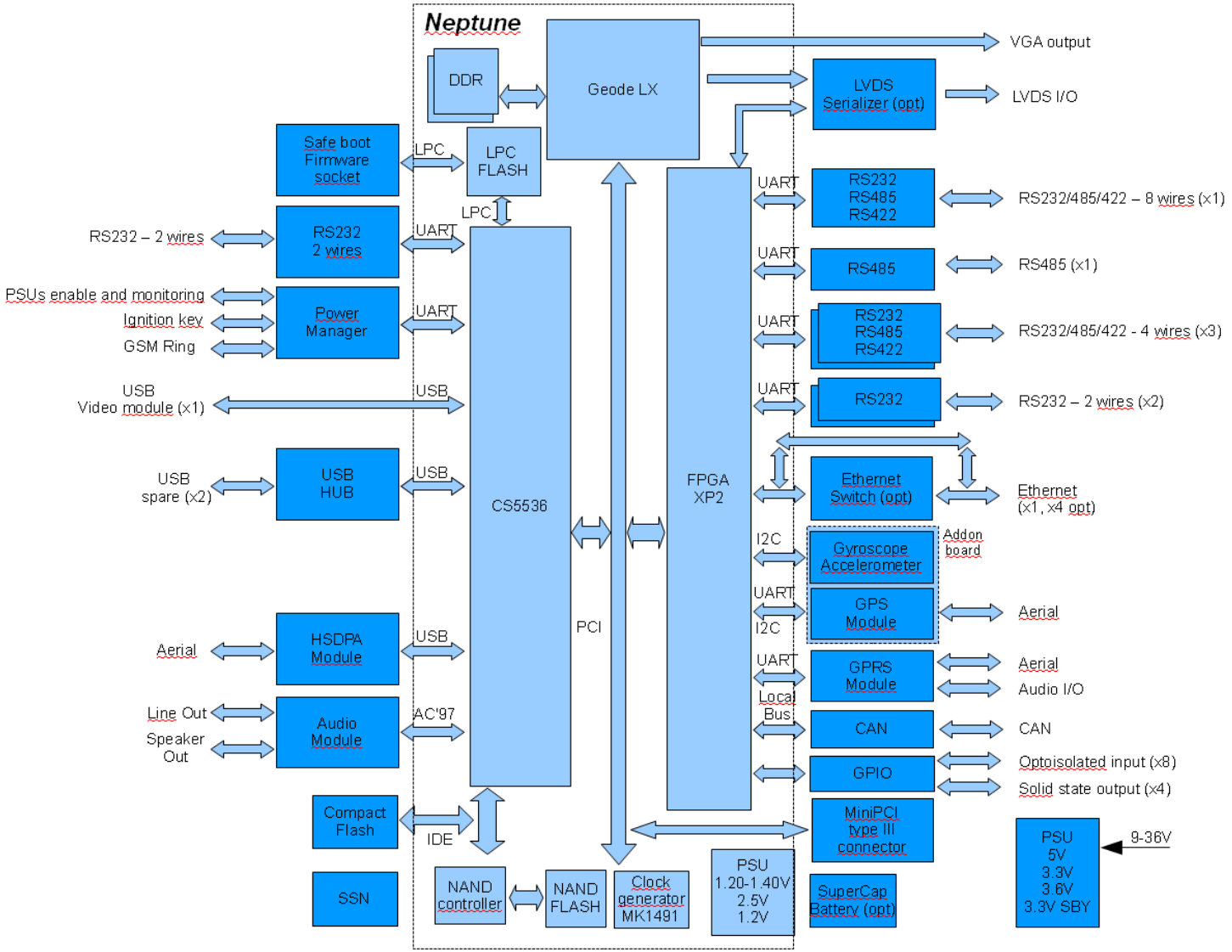
Sistema completo basato su SOM



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Microcontrollori e LCD

L'idea che sta alla base è la possibilità di aggiungere “potenzialità grafiche” evolute ad applicazioni microcontroller-based con un controllore grafico implementato in FPGA:

- potente (varie icone, piani grafici, video scaling)
- semplice da utilizzare (controllo via SPI)
- facilmente integrabile

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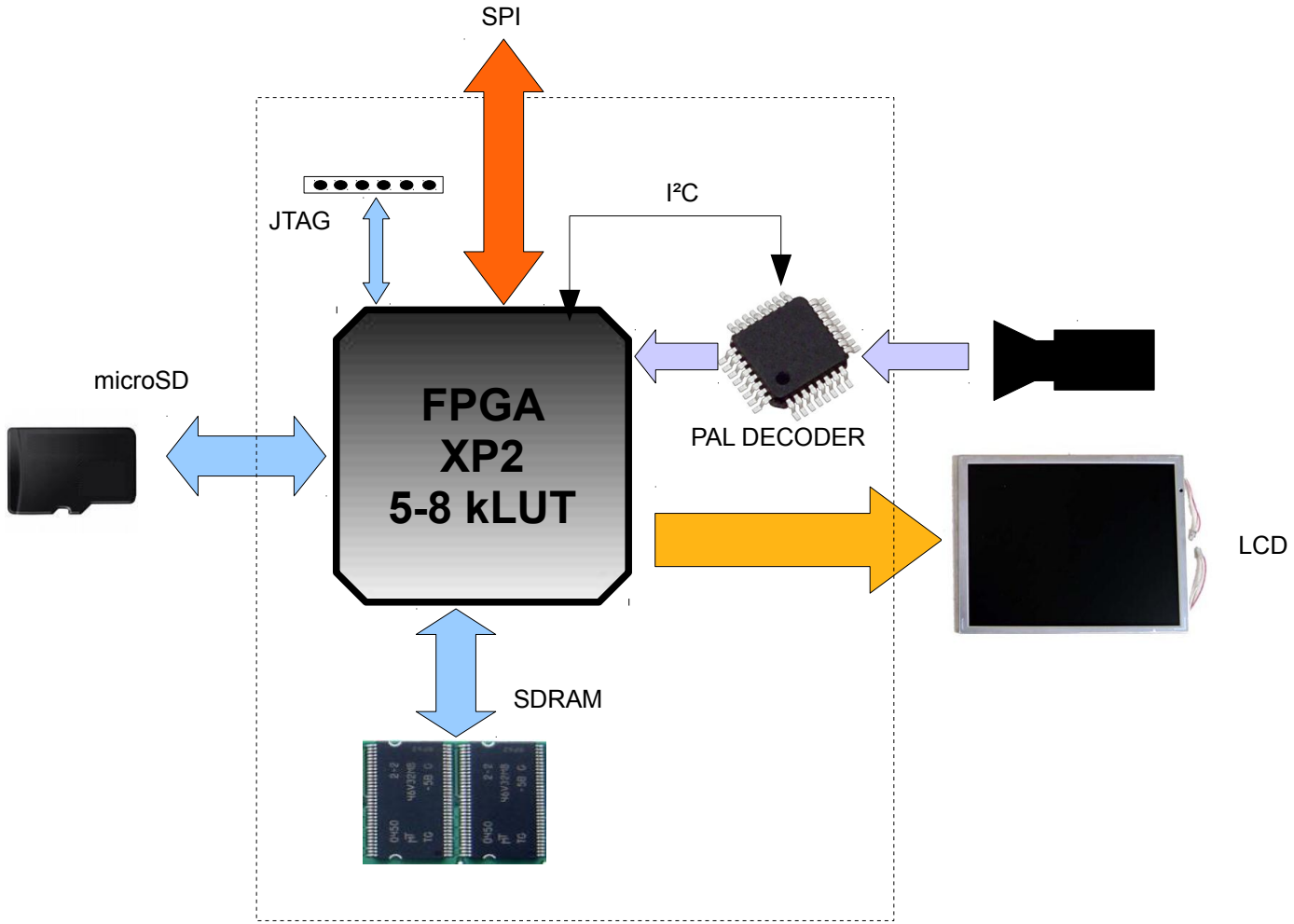
Sistema completo: DBD



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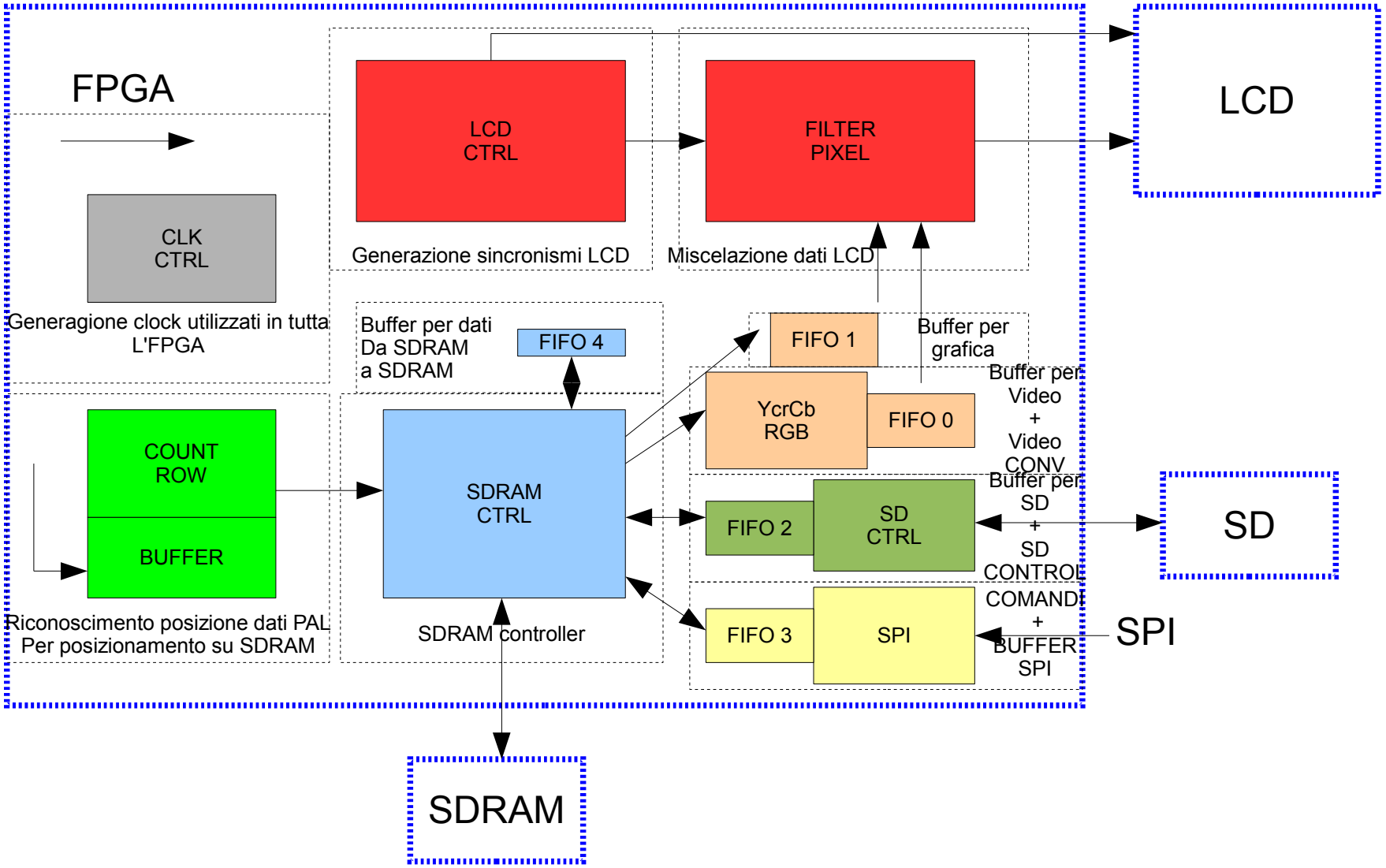
System example: DBD



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Interfacciamento LCD e video

- Formati video 4/3 o 16/9 nativi con relativo scaling
- 2 piani grafici (primopiano e background) e un piano video
  - video scalabile e fluido a 50Hz
  - grafica sincronizzata con il video

- Praticamente qualsiasi tipo di LCD: varie interfacce elettriche, e risoluzioni grafiche ¼ VGA, VGA, SVGA....
- Composizione della grafica a pixel o ad icone (fino a 8192)
  - icone caricate via SPI (dal micro) o dalla SD

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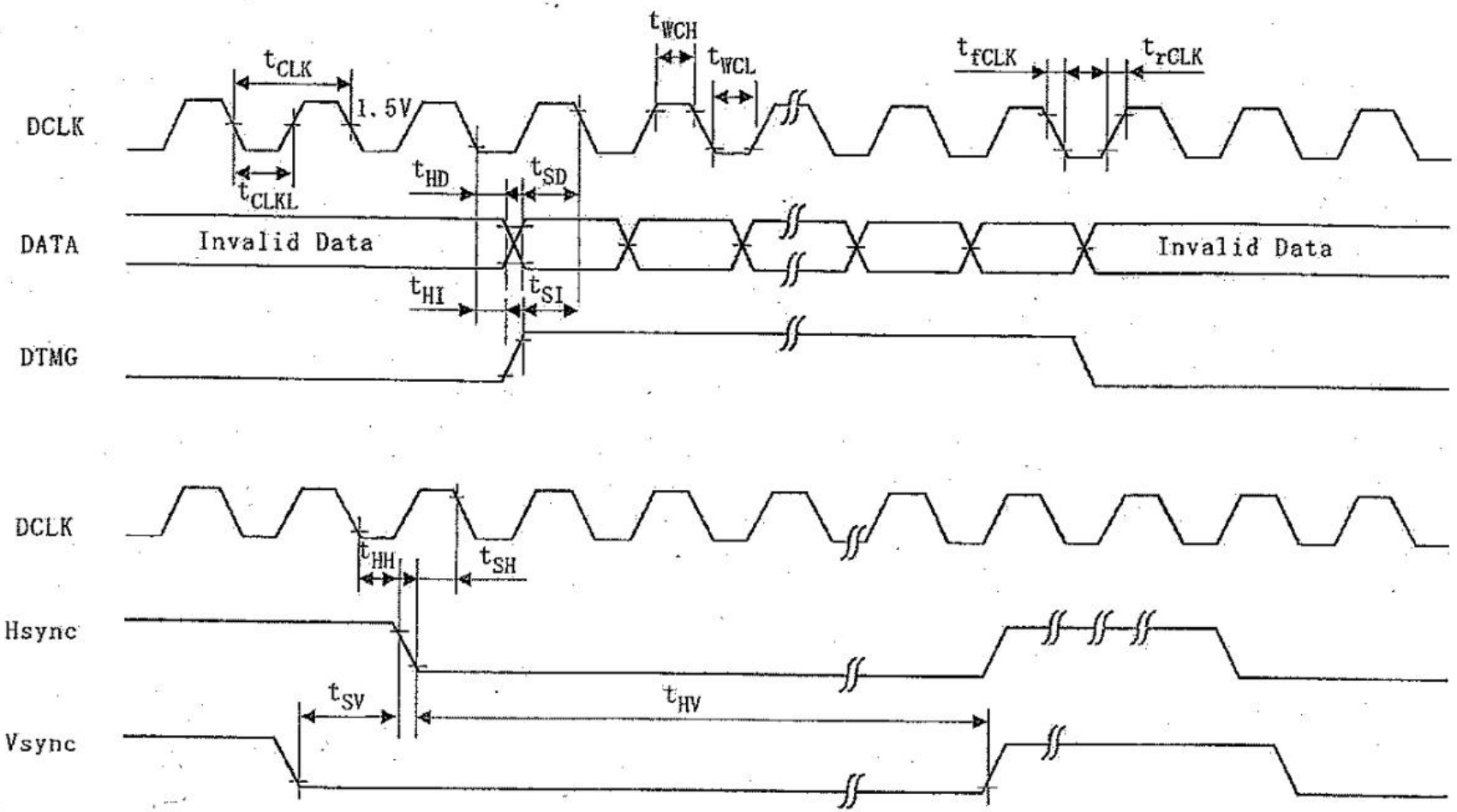
Interfacciamento LCD e video



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Funzionalita' principali e applicazioni

- disegno di punti, linee, rettangoli (fill), colorazioni
  - primitive di copia tra piani grafici, da RAM, da SD
- i fotogrammi possono essere immagazzinati in SD o letti via SPI
- i fotogrammi possono essere richiamati da SD e ripresentati su LCD
- Applicazioni
  - Video sorveglianza
  - Cruscotti automotive
  - HMI industriali a bassa entropia di segnale (no testo)
  - Terminali domotici di video comunicazione
  - Framers e affini...
  - Pannelli di controllo pseudo-statici

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Tre tipologie principali

- “while(true)”
- RTOS
- General purpose o.s. (opportunamente adattato)

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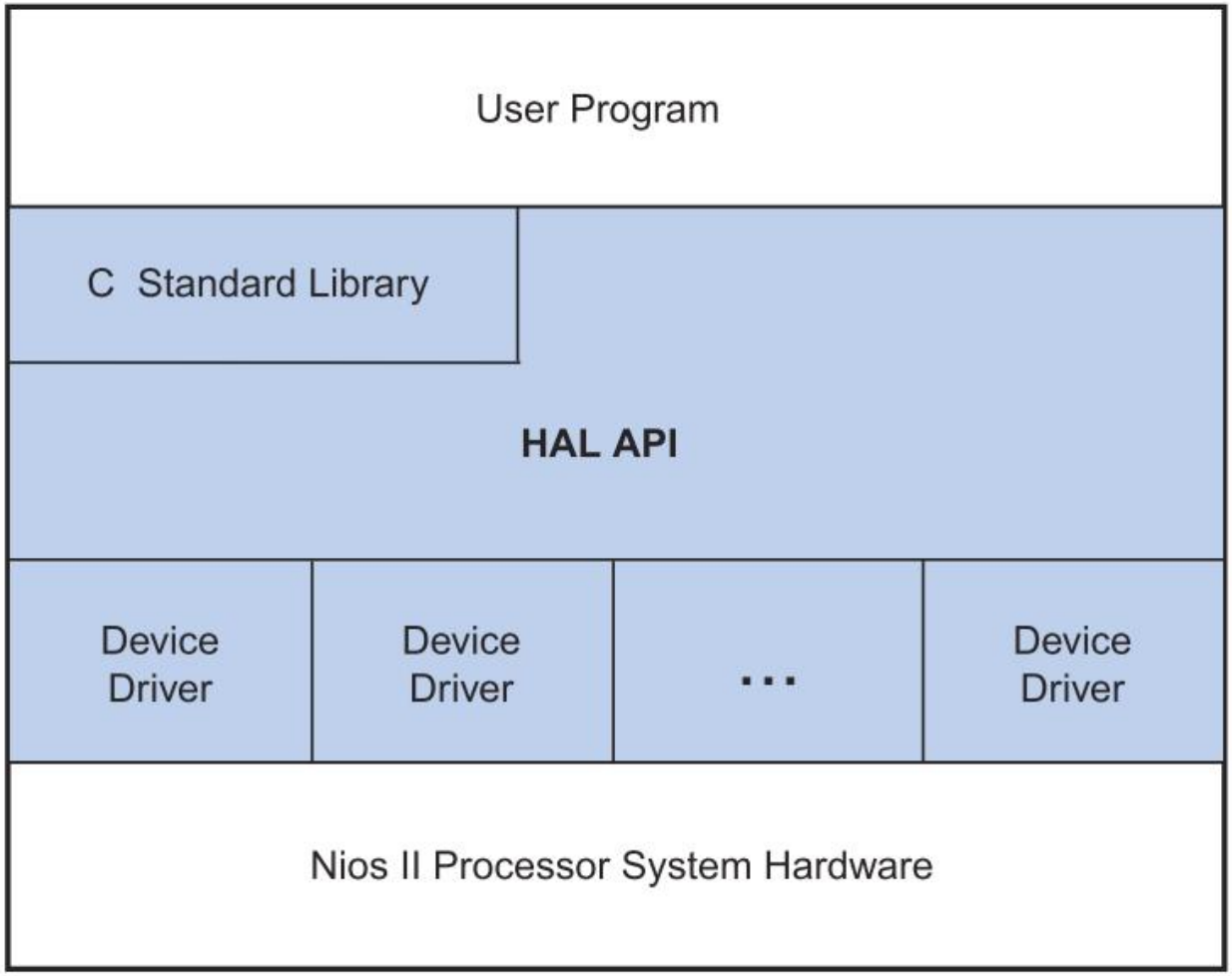
Architetture software: “while (true)”



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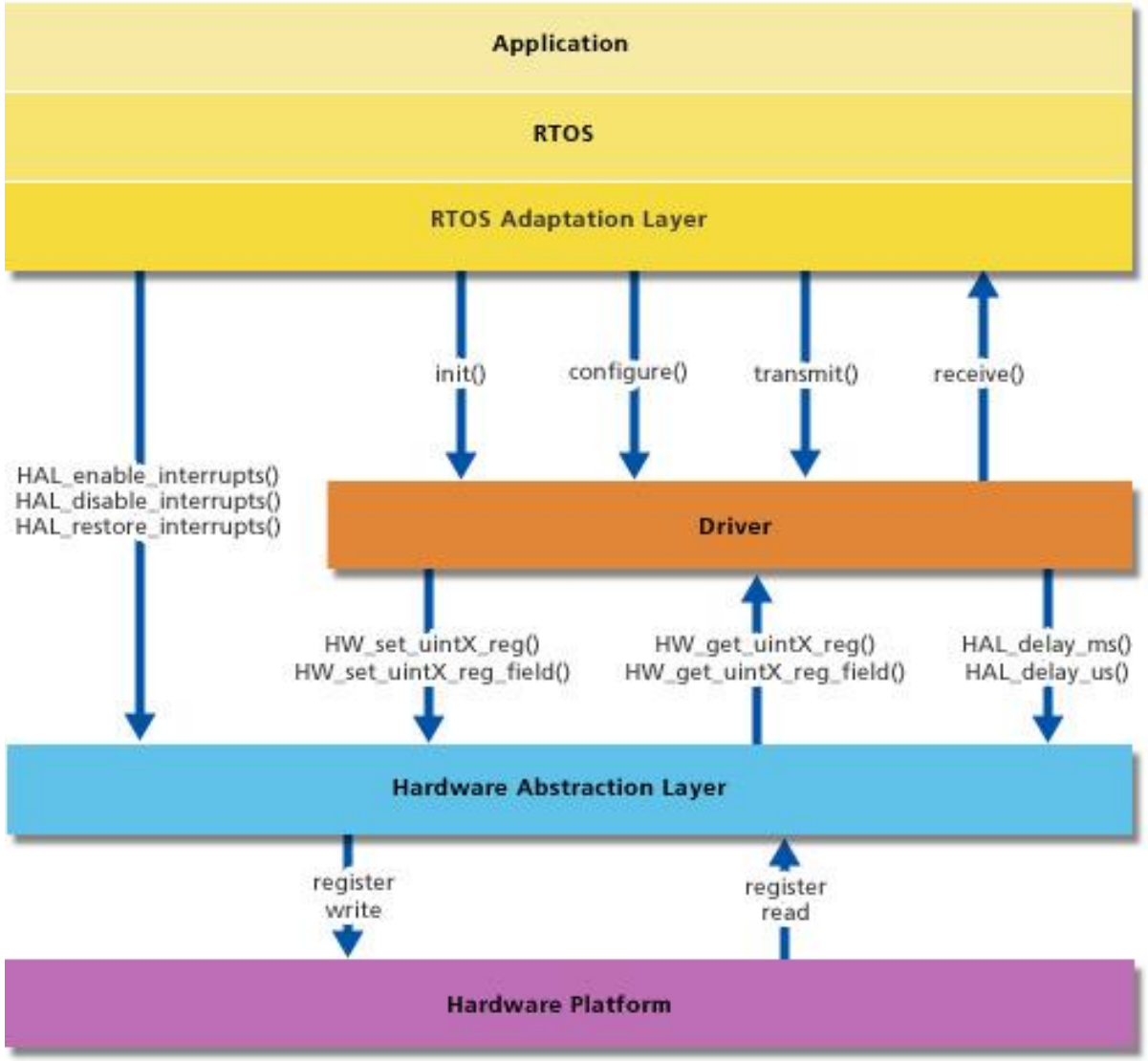
Architetture software: RTOS

RTOS

- eCos
- QNX
- VxWorks
- uUC/OS II
- ...



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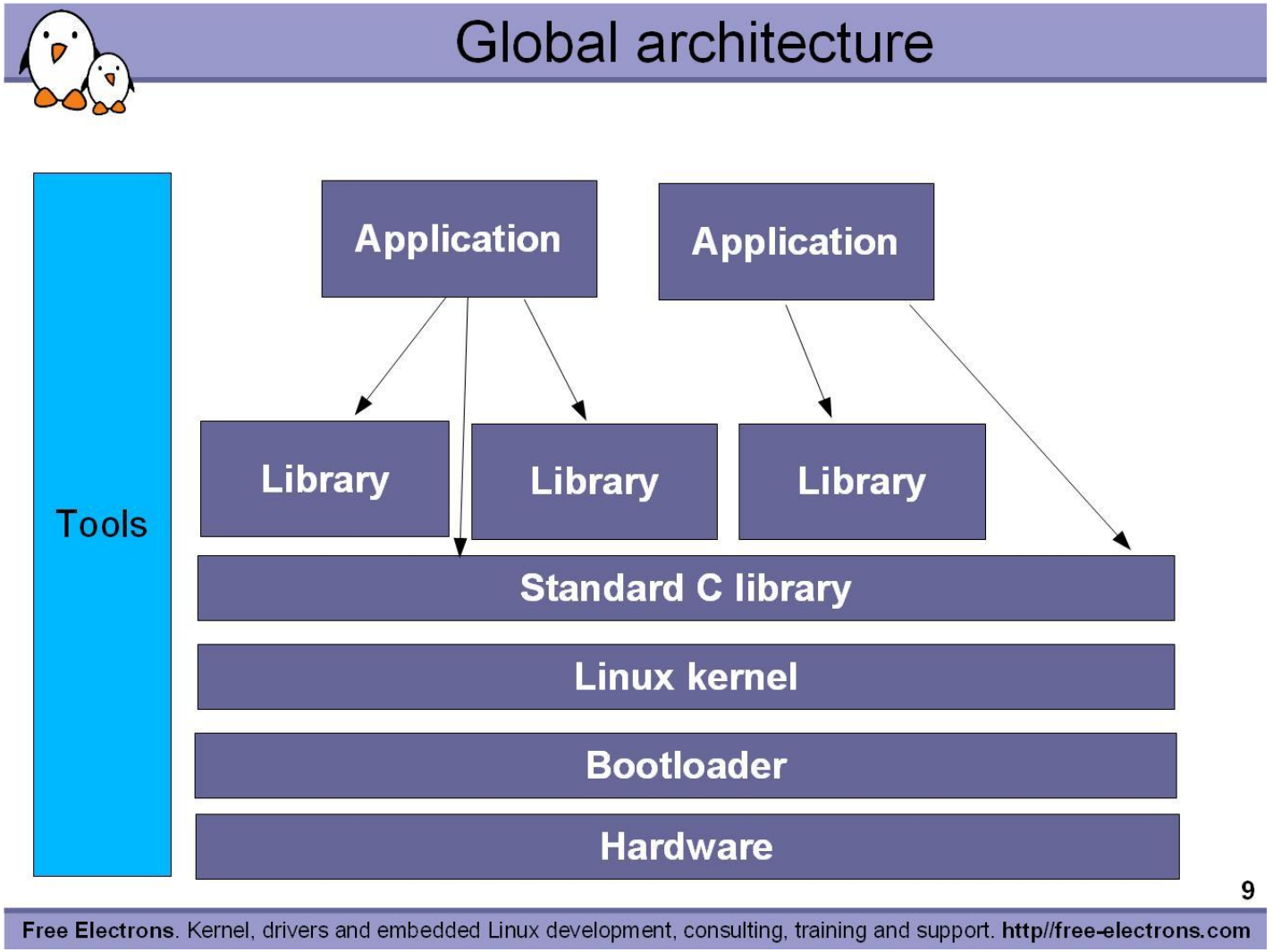
Global architecture
Application
Application
Tools
Library
Library
Library
Standard C library
Linux kernel
Bootloader
Hardware
9
Free Electrons. Kernel, drivers and embedded Linux development, consulting, training and support. http//free-electrons.com

Embedded hardware

- Hardware for embedded systems is often different from hardware for classical systems.
  - Often a different CPU architecture: often ARM, MIPS or PowerPC. x86 is also used.
  - Storage on flash storage, NOR or NAND type, often with limited capacity (from a few MB to hundreds of MB)
  - Limited RAM capacity (from a few MB to several tens of MB)
  - Many interconnect bus not often found on the desktop: I2C, SPI, SSP, CAN, etc.
- Development boards starting from a few hundreds of EUR / USD
  - Often used as a basis for the final board design.

Minimum requirements

- A CPU supported by gcc and the Linux kernel
  - 32 bit CPU
  - MMU-less CPUs are also supported, through the uClinux project.
- A few MB of RAM, from 4 MB.
  8 MB are needed to do really do something.
- A few MB of storage, from 2 MB.
  4 MB to really do something.
- Linux isn't designed for small microcontrollers that just have a few tens or hundreds of KB of flash and RAM.
  - Base metal, no OS
  - Reduced systems, such as FreeRTOS

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Software components

- Cross-compilation toolchain
  - Compiler that runs on the development machine, but generates code for the target
- Bootloader
  - Started by the hardware, responsible for basic initialization, loading and executing the kernel
- Linux Kernel
  - Contains the process and memory management, network stack, device drivers and provides services to userspace applications
- C library
  - The interface between the kernel and the userspace applications
- Libraries and applications
  - Third-party or in-house

Embedded Linux work

Several distinct tasks are needed when deploying embedded Linux in a product

- **Board Support Package development**
  - A BSP contains a bootloader and kernel with the suitable device drivers for the targeted hardware
  - Purpose of our « Kernel Development » training
- **System integration**
  - Integrate all the components, bootloader, kernel, third-party libraries and applications and in-house applications into a working system
  - Purpose of this training
- **Development of applications**
  - Normal Linux applications, but using specifically chosen libraries

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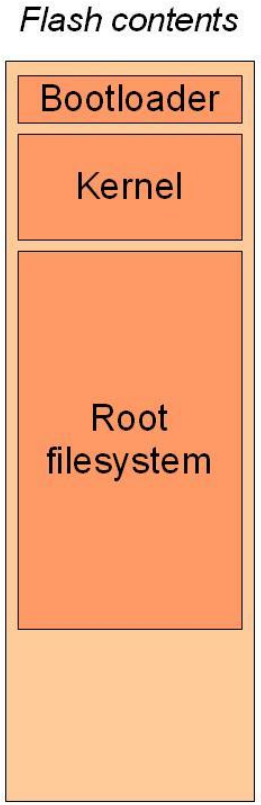
Root filesystem

- In a Linux system, several filesystems are mounted and create a global hierarchy of files and directories
- A particular filesystem, the root filesystem, is mounted as /
- On embedded systems, this root filesystem contains all the libraries, applications and data of the system
- Therefore, building the root filesystem is one of the main tasks of integrating embedded Linux components into a device
- The kernel is usually kept separate



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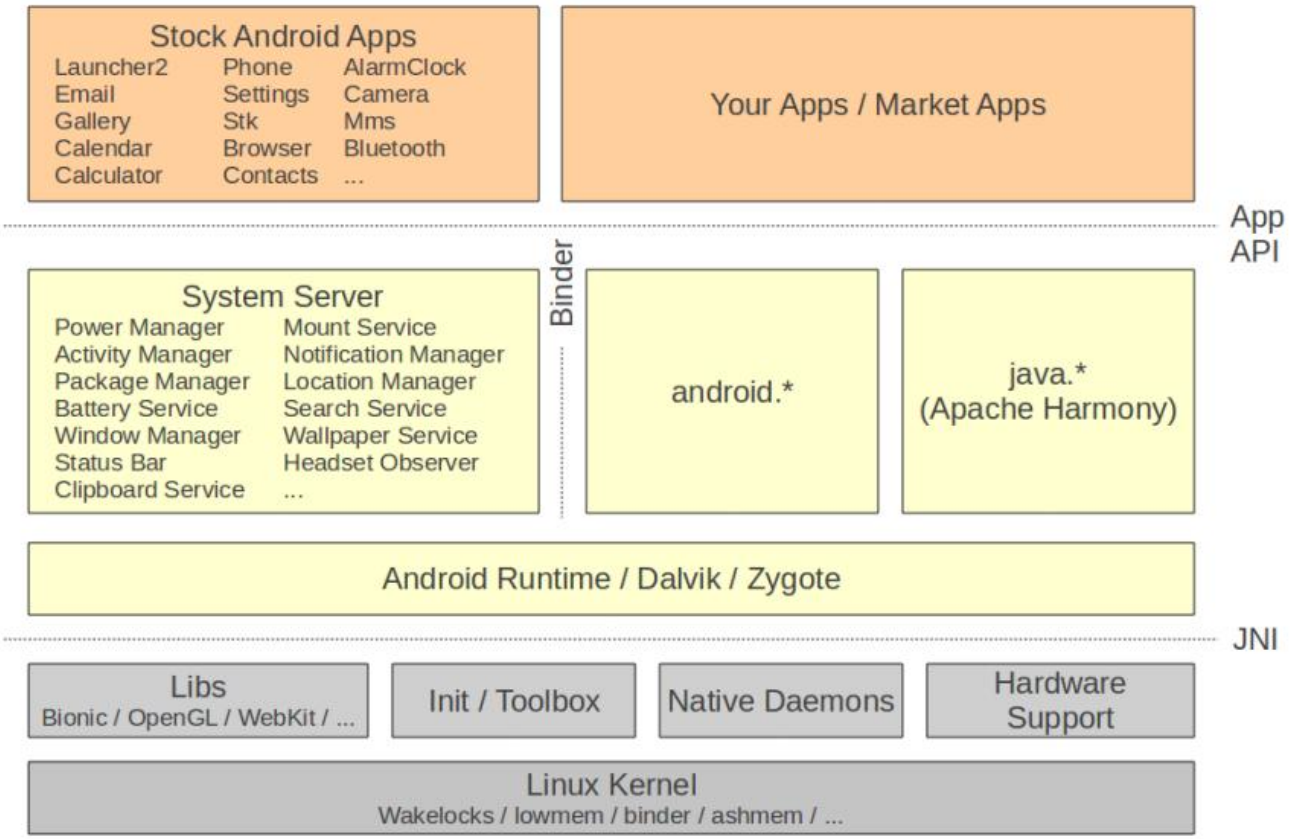
4.2. Overall Architecture - Android



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Tesi di laurea/stage/tirocini

Collaborazioni con atenei ed enti di ricerca

- Universita' di Trieste
- Universita' di Padova
- Universita' di Udine
- Sincrotrone
- CNR Ferrara – IMAMOTER

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Proposte tesi di laurea

- applicabili sia ai corsi triennali sia alle lauree specialistiche quinquennali
- l'argomento trattato viene modulato in maniera opportuna, in accordo con lo studente, affinché il contenuto sia congruo con il percorso accademico del laureando
- possibilita' da parte del laureando e del relatore di proporre delle variazioni
- previsto un periodo di presenza fisica presso i laboratori dell'azienda
- un premio di laurea che verrà corrisposto al laureando in caso il correlatore aziendale giudichi positivamente i risultati raggiunti
- la tesi sperimentale risulta essere molto efficace anche come strumento di selezione del personale (al momento della stesura di queta presentazione - Marzo 2012 - il 60% delle risorse del reparto di ricerca e sviluppo di DAVE è composto da personale che è stato inserito nell'organico immediatamente dopo aver svolto la tesi sperimentale

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Proposta tesi di laurea #1

Proposta: Implementazione in FPGA di un echo canceller per applicazioni industriali e civili

Descrizione: Partendo da un sistema funzionante in grado di processare un flusso video proveniente da una telecamera analogica, l'obiettivo è quello di completarlo realizzando in FPGA la funzione di echo cancelling relativa al flusso audio, previa conversione analogico/digitale. Il tesista dovrà cercare di sfruttare al meglio le risorse hardware messe a disposizione dal dispositivo, in modo da massimizzare l'efficienza dell'implementazione in termini di area.

Keywords: FPGA, DSP, echo canceller, DAC, ADC.

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Proposta tesi di laurea #2

Proposta: Implementazione di un controllore di memoria mista (DDR/NAND) con massimizzazione di banda e/o affidabilità per storage dati su dispositivo a stato solido

Descrizione: Lo scopo della tesi è quello di progettare (lato memorie) un sistema di storage a stato solido ad alto throughput ed affidabilità, facendo affidamento non solo sulle memorie NAND di tipo TLC/MLC/SLC ma anche su un buffer RAM (implementabile in DDR2-3) in modo da massimizzarne le prestazioni. La tamponabilità del sistema, la parallelizzazione delle NAND a valle della RAM, l'interfacciabilità del sistema alle più varie interfacce seriali possibili, la possibilità di scambiare l'affidabilità in funzione della velocità di storage sono varianti che garantiscono al sistema un valore aggiunto fondamentale per la rivendibilità di un dispositivo per sè abbastanza standard.

Keywords: SSD, FPGA, high reliability, SSD controllers, S.M.A.R.T.

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Proposta tesi di laurea #3

Progettazione e realizzazione di un computer-on-module (COM) per applicazioni industriali

Descrizione: Lo scopo della tesi è quello di partecipare, come membro del team di sviluppo, alla progettazione e realizzazione di un computer-on-module (COM) per applicazioni industriali, basato sul processore embedded Texas Instruments AM335x. Il laureando verrà quindi a trovarsi di fronte ad un ampio spettro di problematiche relative alla progettazione hardware, comprendenti ad esempio:

- **l'interfacciamento di dispositivi digitali complessi**
- **l'analisi della signal/power integrity e della conseguente progettazione del PCB**
- **il dimensionamento di stadi di alimentazione switching DC/DC**
- **l'analisi termica**
- **le metodologie di validazione**
- **il processo produttivo.**

Keywords: embedded processor, PCB, signal integrity, alimentatori DC/DC, progettazione digitale.

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Q&A

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