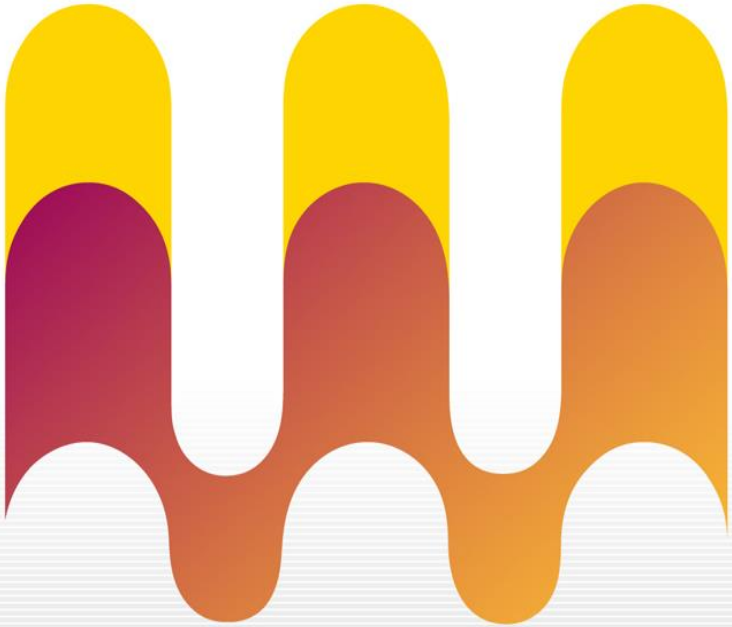


EVIDENCE®

EMBEDDING TECHNOLOGY

Technological challenges in the multicore era

Claudio Scordino, PhD

About Evidence Srl

- Founded in 2002 as spin-off company of the Real-Time Systems Lab at Scuola Superiore S.Anna
  - ~22 qualified people with an average age of 38 years
  - 15+ years of experience in academic and industrial projects
  - ~ 30% has a PhD degree

Impresa Spin-Off della Scuola Sant'Anna

Our Mission:
We design and develop complex software for embedded real-time devices

We offer:

... a dynamic & innovative environment

... in a family of 22 people in Pisa

... chance of working on Linux kernel, RTOSs, device drivers

We look for:

and:

... a MS degree in Computer Engineering or Computer Science

... excellent knowledge of:

- C programming
- operating systems
- computer architectures

ERIKA Enterprise

http://www.erika-enterprise.com

https://github.com/evidence/erika3

- RTOS developed by Evidence for automotive ECUs
- Minimal footprint (few KBs) and multi-core support
- Certifications: OSEK/VDX, ISO26262 (ASIL B in-progress)
- Reference standard: MISRA-C, AUTOSAR OS
- Dual licensing: GPL and commercial
- Used by various companies and research projects

AUTOSAR

MAGNETI MARELLI

Vodafone Automotive

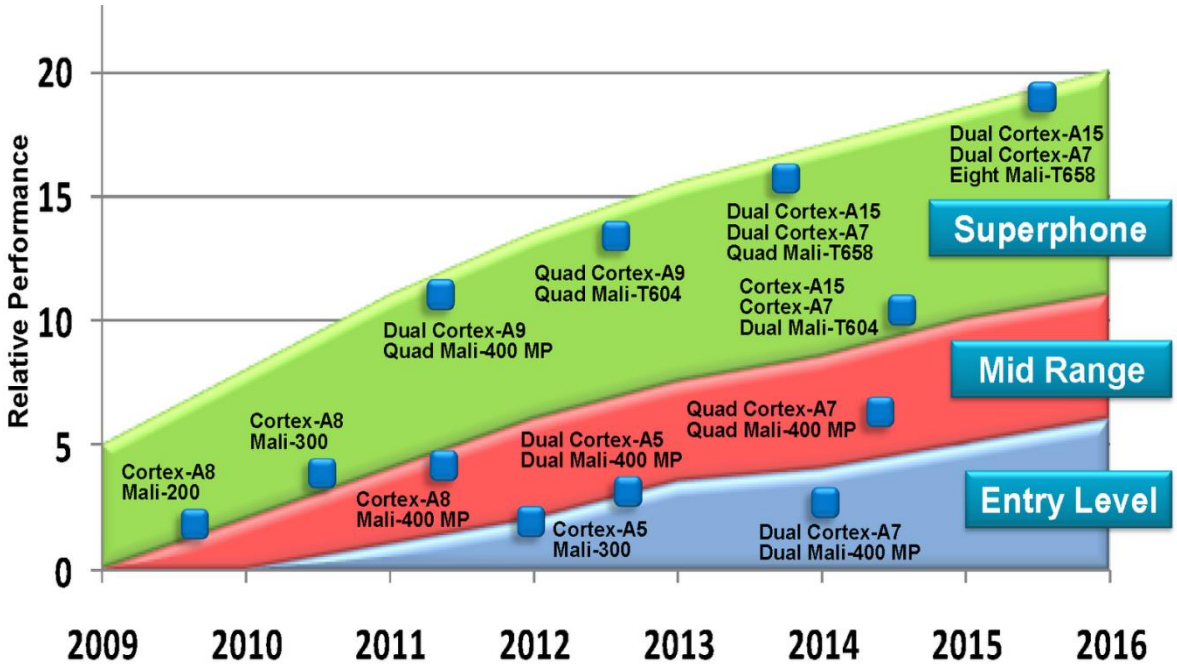
ARISTON THERMO GROUP

PIAGGIO

Linux kernel

- Deep knowledge of kernel internals
  - Including real-time extensions (Xenomai, PREEMPT_RT)
- Constant collaboration with the kernel community
  - Among the organizers of the OSPM Summit
  - Since 2008 officially among the Linux kernel contributors
- SCHED_DEADLINE real-time CPU scheduler:
  - Collaboration with Scuola Sant'Anna and ARM Ltd.
  - http://en.wikipedia.org/wiki/SCHED_DEADLINE
  - Integrated into the official Linux kernel since 3.14 (2014)

The multi-core revolution



NVIDIA X2:

- Quad-core Cortex-A57
- Dual-core Denver 2
- 3 Cortex-R5
- Pascal GPGPU

NXP i.MX8:

- Dual-core Cortex-A72
- Quad-core Cortex-A53
- Dual-core Cortex-M4F

Xilinx Ultrascale+

- Quad-core Cortex-A53
- Dual-core Cortex-R5
- Mali GPGPU
- Programmable FPGA

Multi-core support in ERIKA

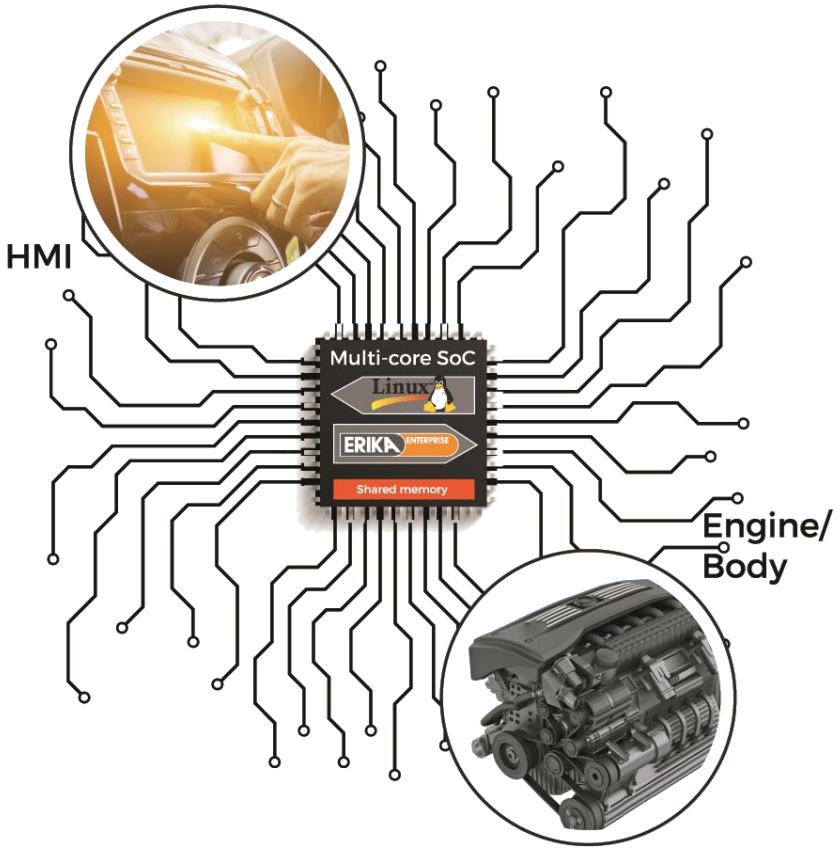
- With version 3, ERIKA has been redesigned to get **full multicore support**:
  - Single kernel image shared among multiple cores
  - Inter-core IRQ and atomic operations on the bus
  - Data and code sharing

- We also added:
  - Simpler makefiles
  - Possibility of library building
  - New mechanism for context switching
  - ISR2 as tasks (memory protection easier)
  - AUTOSAR compliance

Mixed criticality

- How can we get advantage of multi-cores for mixed-criticality ?

- AMP configuration:
  - ERIKA on one core
  - Linux on the other cores
  - Hypervisor ?



Hypervisors

Jailhouse:

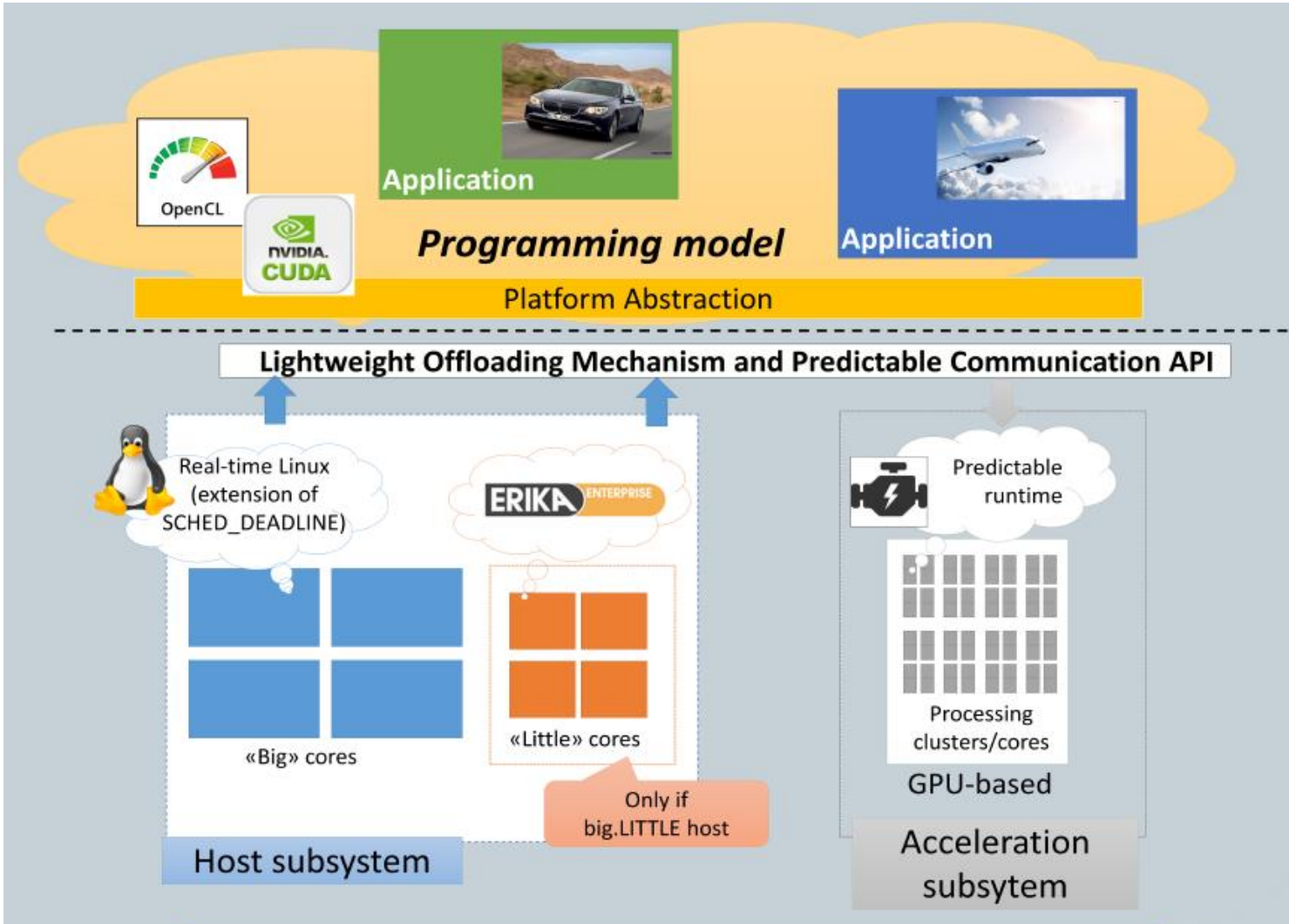
- Developed by Siemens
- Open-Source: https://github.com/siemens/jailhouse
- Small and lightweight:
  - Resource partitioning and isolation
  - Goals: safety-critical & certification
- ERIKA support:
  - NVIDIA TX1/TX2, Xilinx Ultrascale+, x86-64

Xen:

- ERIKA: porting in progress on x86-64

HERCULES H2020 project

- High-performance real-time architecture for low-power embedded systems
- For the Automotive and Avionics domains
- https://hercules2020.eu



Challenges in mixed-criticality

1. Mechanism for communication between OSs
   - Easy-to-use
   - Standard API
   - Real-time

2. Interference on shared hardware resources
   - Examples: caches, buses, memory controller, etc.
   - Can break the real-time guarantees of the RTOS

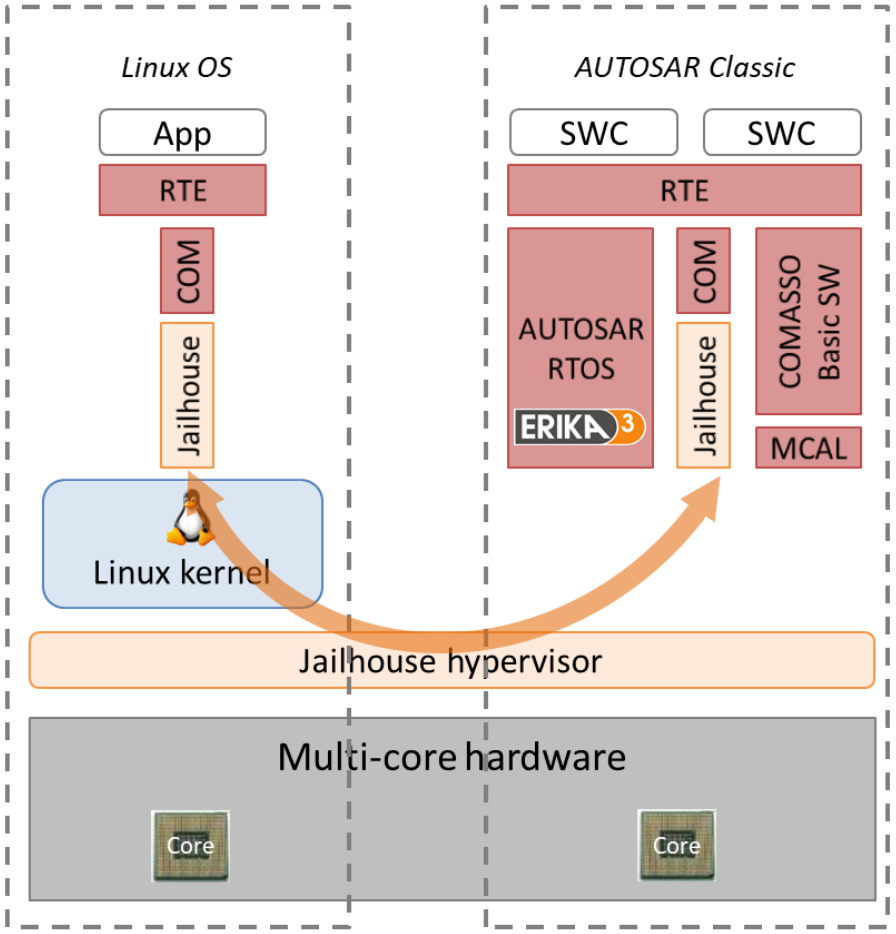
Communication library

In the RETINA EU project we developed a library for communication:

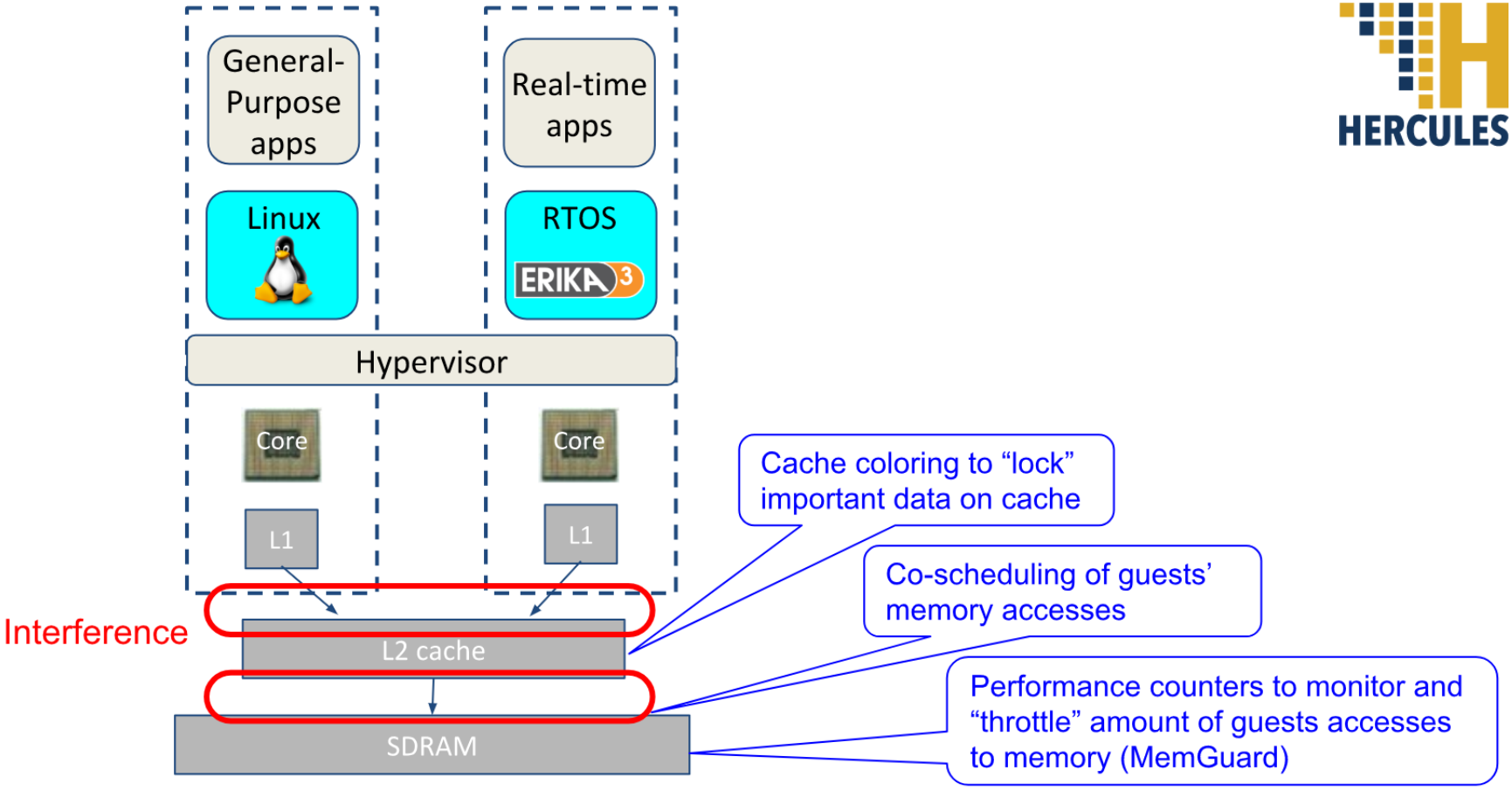
- Based on the AUTOSAR COM standard
- Abstracting the underlying complexity
- Eclipse-based plugin for configuration
- Real-time

RETINA

http://retinaproject.eu



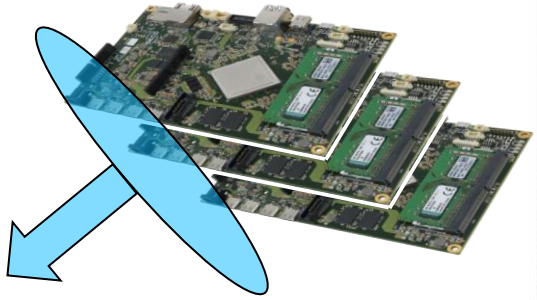
Limiting hardware interference



HERCULES

AXIOM

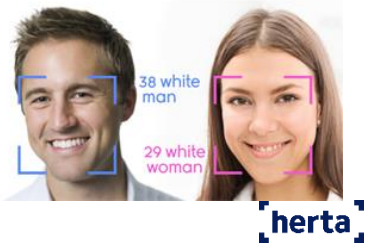
- We designed a small embedded board
  Based on Xilinx Zinq Ultrascale+
  with custom high speed interconnect



- We connect a set of boards together
  using high-speed transceivers
  … RDMA for fast transfers!

- We develop a common programming paradigm
  OmpSs@Cluster → OpenMP on the cluster on top of GASNet
  OmpSs@FPGA → Transparent FPGA acceleration

- We use it for Video and audio processing
  Smart surveillance, speech recognition



http://www.axiom-project.eu

Summary

Small Multi-cores
- ERIKA v3
- Automotive / AUTOSAR
- Static partitioning

Many-cores
- Linux+ERIKA v3
- Predictable OpenMP
- Kalray MPPA
- P-SOCRATES FP7

AMP configuration w/o Hyp.
- Linux + ERIKA on iMX6
- No hypervisor
- 2012 Automotive summit

Cluster configuration
- Linux + OmpSs@cluster
- Custom RDMA device on Xilinx UltraScale+
- QEMU Cluster Emulation

AXIOM

AMP configuration with Hypervisor
- ERIKA v3 + Linux
- Jailhouse on TX1/Parker/ Intel/Ultrascale+, Xen

RETINA

HERCULES

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