



<http://www.axiom-project.eu>

ICT-01-2014 GA 645496

Agile, eXtensible, fast I/O Module for the cyber-physical era



SMART CYBER-PHYSICAL SYSTEMS

START DATE: 01 Feb 2015

DURATION: 3 YEARS

EU FUNDING: 3'946 k €

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University of Siena
(Coordinator Partner)



Barcelona
Supercomputing
Center
Centro Nacional de Supercomputación



FORTH
Institute of Computer Science



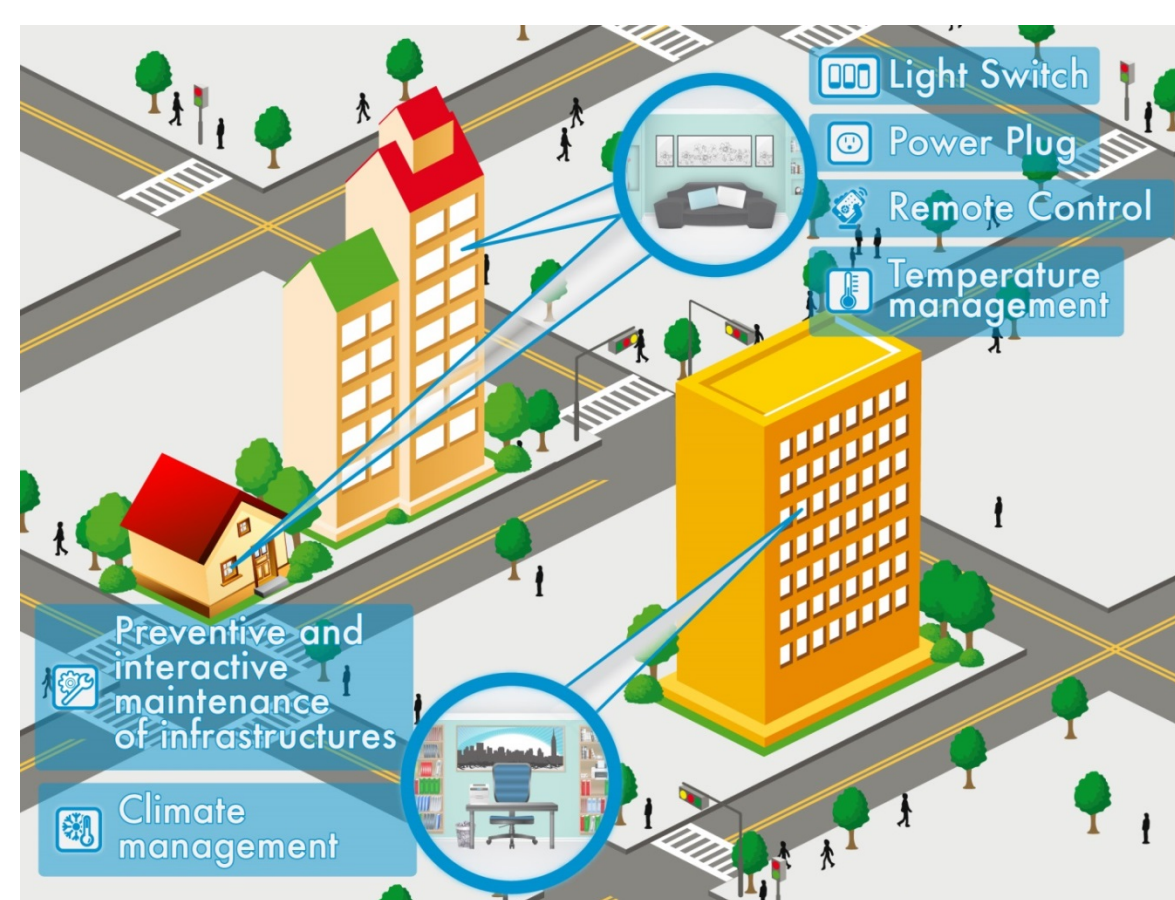
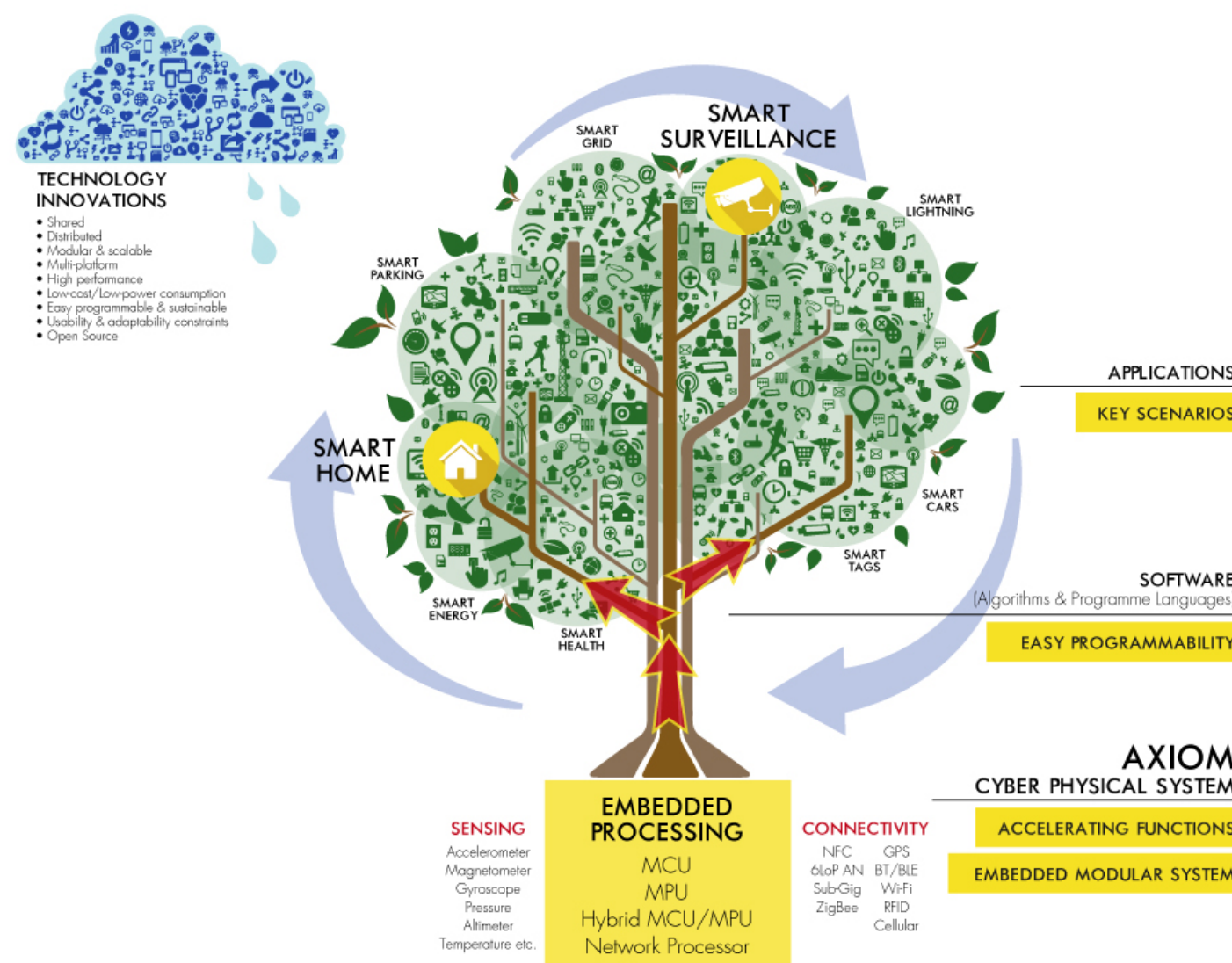
EVIDENCE®
EMBEDDING TECHNOLOGY



VIMAR
energia positiva

GOAL: EU HW/SW DESIGNED AND MANUFACTURED SINGLE-BOARD COMPUTER THAT CAN BECOME THE HEART OF FUTURE SMART APPLICATIONS

WP1: MANAGEMENT, WP2: DISSEMINATION, WP3: SCENARIO DEFINITION AND APPLICATION PORTING



SMART HOME

AXIOM will enable companies, such as VIMAR, to improve real-time data analysis of its Energy Management catalogue and extend the network from the home to a large number of existing or near future services in collaboration with the municipality or even in a peer-to-peer scenario

SMART VIDEOSURVEILLANCE

AXIOM will enable companies, such as HERTA, to deploy their multiple face recognition in real-time in crowded and changeable environments

WP4: PROGRAMMING MODEL

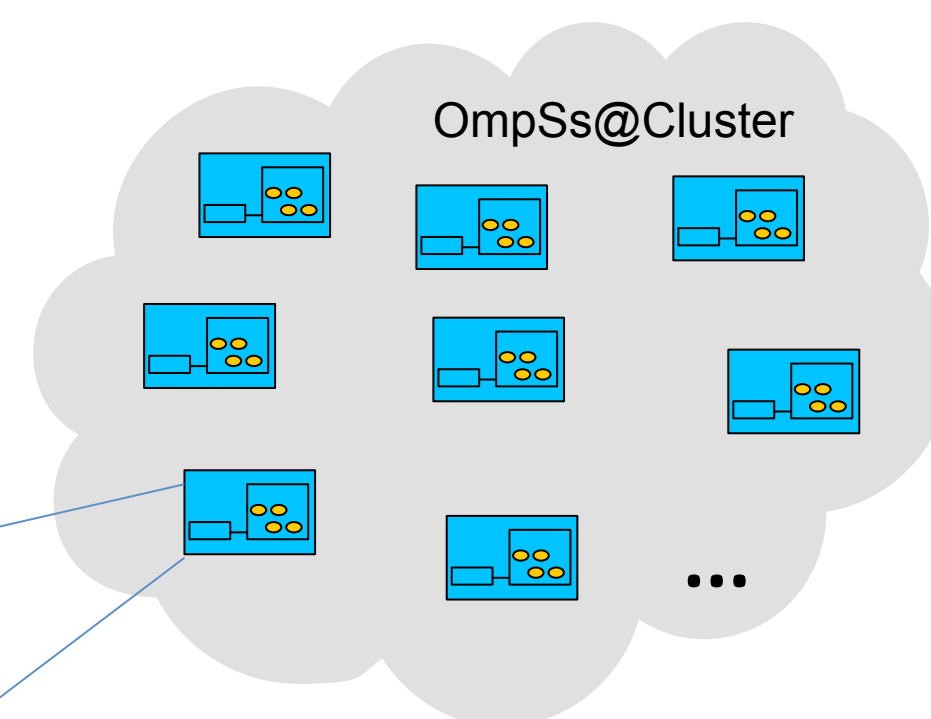
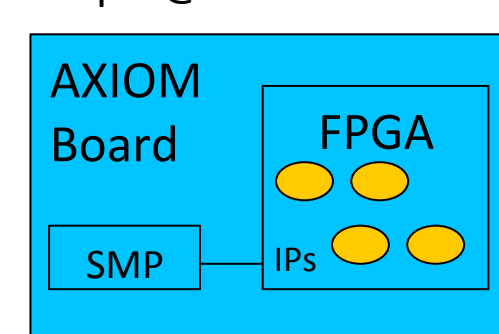
```
1#pragma omp target device(fpga_smp) copy_deps
2#pragma omp task in(a[0:64*64-1], b[0:64*64-1]) \
3    out(c[0:64*64-1])
4 void matrix_multiply(float a[64][64],
5                      float b[64][64],
6                      float out[64][64]) {
7     for (int ia = 0; ia < 64; ++ia) {
8         for (int ib = 0; ib < 64; ++ib) {
9             float sum = 0;
10            for (int id = 0; id < 64; ++id) {
11                sum += a[ia][id] * b[id][ib];
12            }
13            out[ia][ib] = sum;
14        }
15    }
16 int main( void ){
17 ...
18 matrix_multiply(A,B,C1);
19 matrix_multiply(A,B,C2);
20 matrix_multiply(C1,B,D);
21 ...
22#pragma omp taskwait
23 }
```

OmpSs

ADDITIONAL LINES OF CODE:

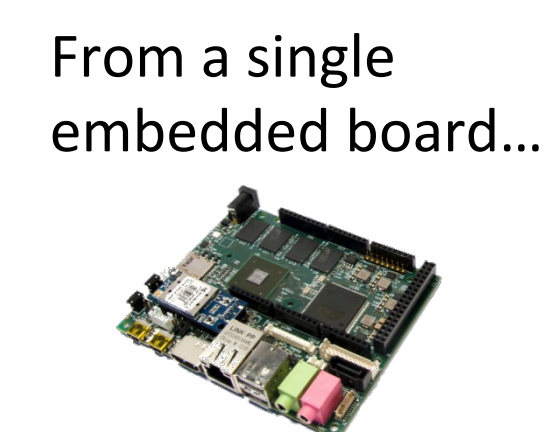
Application	Seq - DMA version	pthread version	OmpSs version
Cholesky	71	26	3
Covariance	94	29	3
64x64	95	39	3
32x32	95	39	3

OmpSs@FPGA

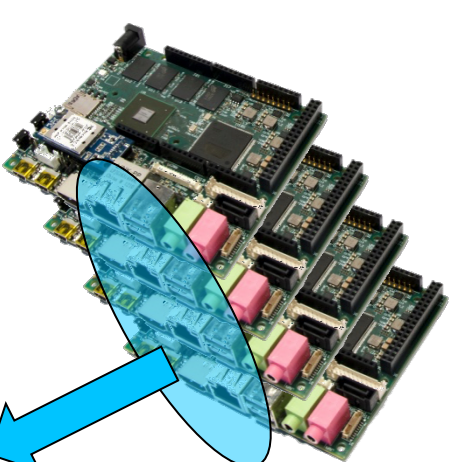
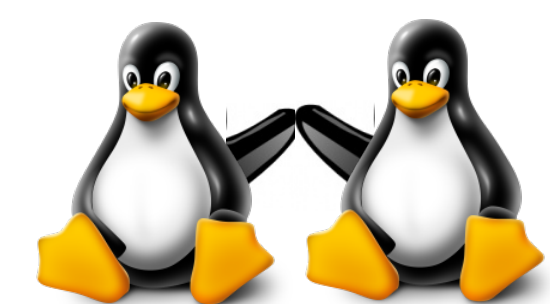


WP5: RUNTIME AND OPERATING SYSTEM

Innovative support for distributed embedded Linux



From a single embedded board...
...to a more powerful system made of small boards or modules

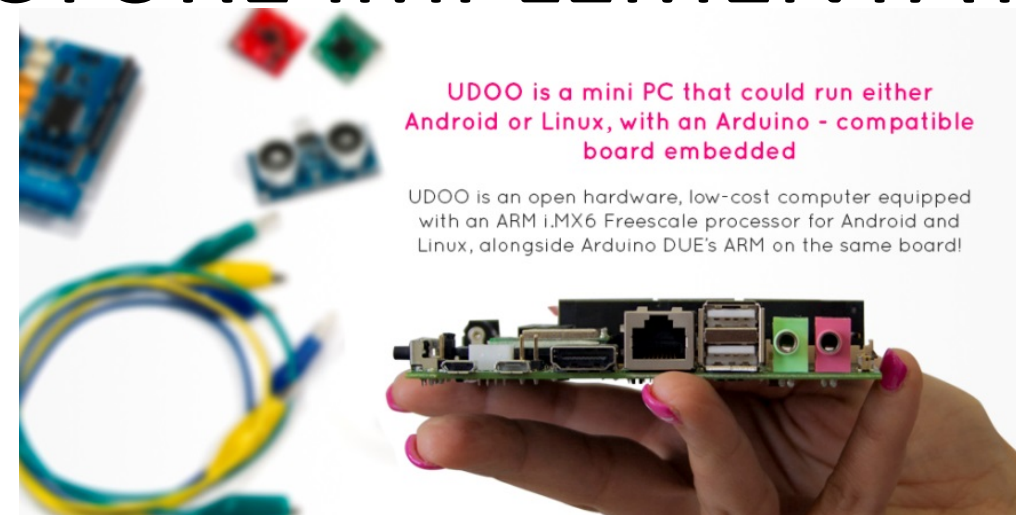


e.g., Distributed Shared Memory based concepts (to be explored further)

WP6: ARCHITECTURE IMPLEMENTATION, WP7: EVALUATION AND DESIGN SPACE EXPLORATION

Starting from a solid base, e.g. UDOO

Architecture design, prototyping, manufacturing



UDOO is a mini PC that could run either Android or Linux, with an Arduino-compatible board embedded

UDOO is an open hardware, low-cost computer equipped with an ARMv7-M FreeScale processor for Android and Linux, alongside Arduino DUE's ARM on the same board!

THE AXIOM MODULE KEY ELEMENTS:

- K1: e.g., ZYNQ FPGA (INCLUDES DUAL ARM A9)
- K2: ARM GP CORE(S)
- K3: HIGH-SPEED & CHEAP INTERCONNECTS
- K4: SW STACK – OMPSS+LINUX BASED
- K5: OTHER I/F (ARDUINO, USB, ETH, WIFI, ...)

INTEGRATING CONSORTIUM EXPERTISE

- VIMAR, HERTA – 2 KILLER APPLICATIONS: SMART HOME AND SMART VIDEOSURVEILLANCE
- SECO – hardware module realization, architecture design
- FORTH – high-speed interconnects, cost effective, ALL the way from IPC acceleration down to the customized data-link protocol and optimized packet formats
- EVI – Runtime, OS (Linux 3.14 real time scheduler)
- BSC – programming models
- UNISI – simulation, evaluation, coordination, architecture

AXIOM OBJECTIVES

OBJ1) Realizing a small board that is flexible, energy-efficient and modularly scalable

- Flexibility: FPGA, fast-and-cheap interconnects based on existing connectors like SATA
- Energy efficiency: low-power ARM, FPGA
- Modularity: fast-interconnects, distributed shared memory across boards

OBJ2) Easy programmability of multi-core, multi-board, FPGA

- Programming model: Improved OmpSs
- Runtime & OS: Improved thread management

OBJ3) Leveraging Open-Source software to manage the board

- Compiler: BSC Mercurium, OS: Linux, Drivers: provided as open-source by partners

OBJ4) Easy Interfacing with the Cyber-Physical Worlds

- Platform: integrating also Arduino support for a plenty of pluggable boards (so-called "shields")
- Platform: building on the UDOO experience of SECO

OBJ5) Enabling real time movement of threads

- Runtime: will leverage the EVIDENCE's SCHED_DEADLINE scheduler (i.e. EDF) included Linux 3.14, UNISI low-level thread management techniques

OBJ6) Contribution to Standards

- Hardware: SECO is founding member of the Standardization Group for Embedded Systems (SGET)
- Software: BSC is member of the OpenMP consortium

TOWARDS HPC+EMBEDDED CONVERGENCE

