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IETR

Institut d'Electronique et des Technologies du numéRique

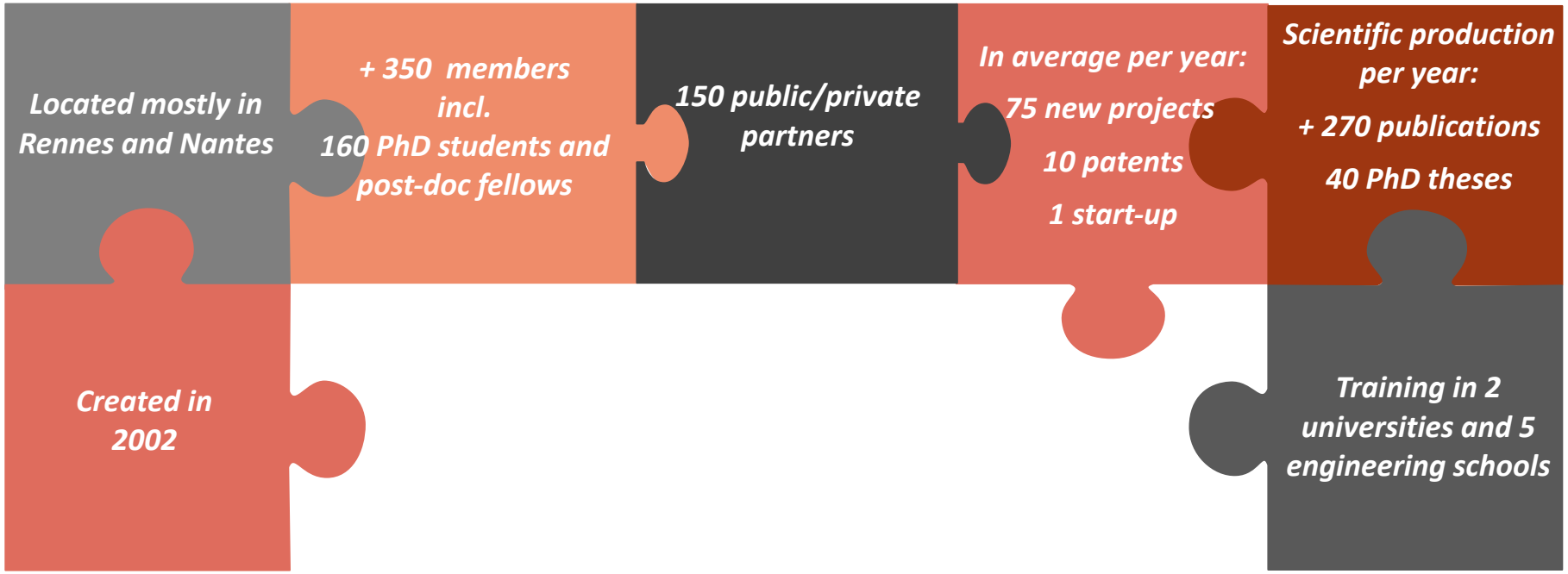
Research institute in Electronics and Digital Technologies

CentraleSupélec
INSA RENNES
Nantes Université
Université de Rennes

15/02/2023

www.ietr.fr

Who are we?



Innovative solutions for your projects in
digital sciences, security, energy, health, environment and mobilities

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Societal challenges and applications

Digital infrastructures and communications

Health, Well-

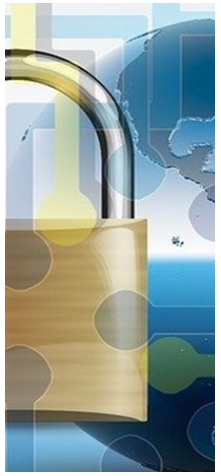
Mobilities

Industry 4.0

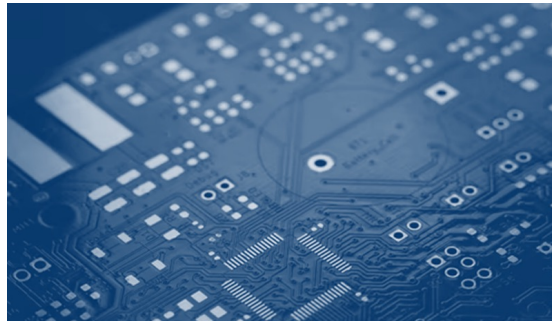
Environment

Energy

Hardware cybersecurity

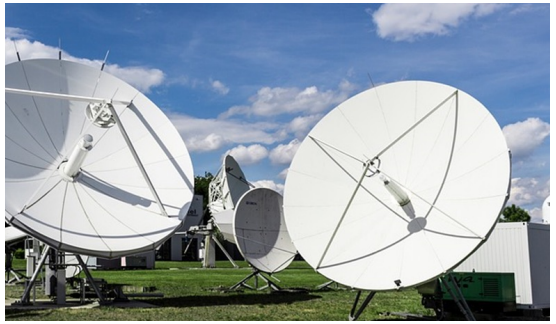


8 complementary research domains (1/2)



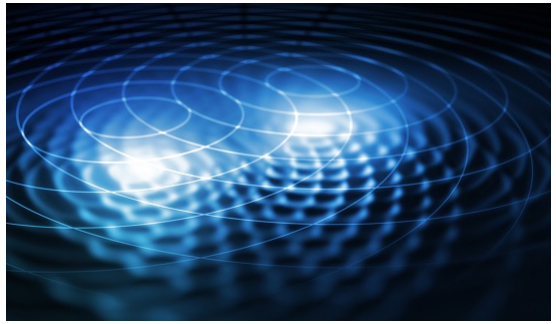
Micro-technologies, Materials and sensors

- Micro- and nano-technologies (silicon, glass, plastic, flexible materials, etc.)
- Inorganic, organic and biosourced materials
- Flexible / stretchable electronics
- 3D objects
- Micro-sensors (mechanical, chemical, biological, etc.)
- Energy storage and harvesting



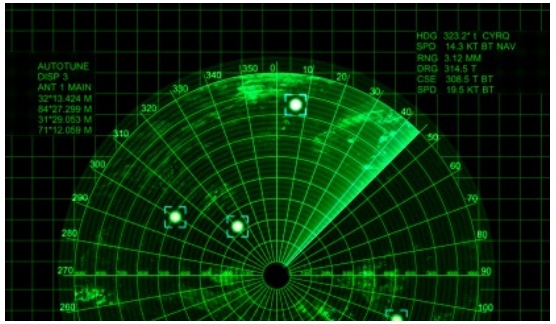
Antennas and complex radiating systems

- Ultra-miniatures antennas
- Antenna arrays (passive, reconfigurable, beam steering, etc.)
- Millimeter-waves and THz
- Metasurfaces
- Periodic and non-periodic structures (RIS, RA, TA, FSS, WAIM, etc.)
- Active surfaces for communications & sensing
- Antennas on non-standard substrates



Complex interactions of waves with matter and living organisms

- Control of electromagnetic (EM) waves in random media
- EM imaging
- EM compatibility
- EM cybersecurity
- Communicating devices
- Miniature implantable sensors
- Wave interactions with living organisms
- EM dosimetry



Propagation and radar technologies, detection, location

- Radar systems
- Environmental monitoring
- Airborne and spaceborne radar systems for remote sensing applications
- Propagation studies
- Geolocation

8 complementary research domains (2/2)

Communication systems, digital networks and equipment

- 5G+, 6G+
- Digital communications
- Smart connectivity
- Spectral and energy efficiencies
- Waveforms
- Signal Processing
- Learning
- Cognitive radio
- Software-defined radio

Smart embedded, reliable and flexible intelligents systems,

- Architectures and design tools
- Embedded communication systems
- Embedded AI
- Connected AI
- Reliability
- Hardware security

Image Processing, video codec, and artificial intelligence

- Signal and Image Processing
- Hyperspectral Imaging
- Artificial intelligence
- Video compression
- Affective computing

Control science for energy transition

- Control systems
- Stochastic methods
- Model predictive control
- Adaptive control
- Energy efficiency
- Energy management

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Main experimental core facilities (1/4)

Micro- and nanotechnologies, Materials

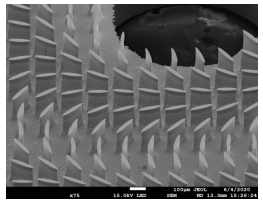
Micro and nanotechnologies

Main facilities

- 400 m² (incl. 120 m² clean rooms)

Some specific features

- Microelectronic devices on Silicon, glass, plastics, etc.
- Micro- and nano-machining
- Flexible and stretchable printed electronics
- 3D electronics
- Organic electronics
- Electric, topological and optical characterization



Contact: maxime.harnois@univ-rennes1.fr

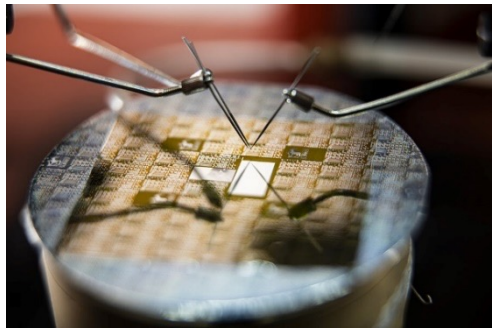
Multifunctional materials

Main facilities

- 500 m² (incl. 45 m² clean rooms)

Some specific features

- Ferroelectric, antiferroelectric and piezoelectric materials
- Electroactive polymers
- Flexible ceramic thin films
- Conducting composites
- Transparent conductors
- Physicochemical, topological and electromagnetic characterization



Contacts: hartmut.gundel@univ-nantes.fr ; claire.lepaven@univ-rennes1.fr

Main experimental core facilities (2/4)

EM waves, Antenna systems, EMC, Propagation

Antenna systems: characterisations up to 500 GHz

- Near-field and far-field measurement techniques
- 6 anechoic chambers, 1 compact antenna test range

Characterisations: radiated mode, propagation media, materials, targets

- Back scatterring
- RCS measurement
- Imaging techniques
- Material characterisation (free space)
- Reverberation chambers

Analysis and modeling: development of new instruments

- Multiphysics dosimetry for bioelectromagnetics
- New measurement systems for antenna charact. and radars
- In-house control and post-processing software

Prototyping and metrology

- Metrology up to 500 GHz
- Mechanics and micro-mechanics: CNC machines, EDM, 3D printing
- PCB: laser ablation, micro-milling, chemical etching, etc.

Contacts: philippe.besnier@insa-rennes.fr ; marc.brunet@univ-nantes.fr ; laurent.le-coq@univ-rennes1.fr

Main experimental core facilities (3/4)

Radar systems, Embedded systems, Connectivity and Data

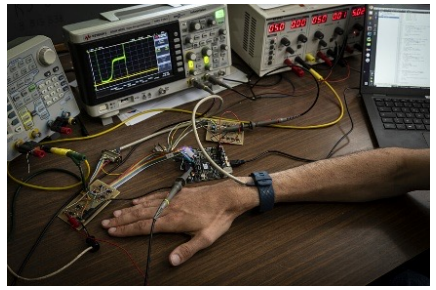
Airborne Multimodal Engineering Platform (PIMA)

- Aircraft (Flight Design - CTLS 100)
- Airfield (runway, taxiway, shed)
- Boarding set of sensors covering the full EM spectrum
- Natural environnements: remote sensing and radar SAR imaging
- CalVal (Calibration/Validation) campaigns: spaceborne observation missions

Contact: eric.pottier@univ-rennes1.fr

Platform for connected objects

- Heterogeneous connected nodes (included in FiT IoT-lab)
- Experimentation platform (multipath USRP full-duplex, different computing nodes (ST, ATMEL, TI, panSTAMP, …) and heterogeneous communications)
- High-performance test bench (energy and security)



Contact: sebastien.pillement@univ-nantes.fr

Platform for Hyperspectral Imaging

- Aerial acquisition of orthorectified images calibrated in radiance and/or reflectance
- Extraction of key features from the information content of multimodal images for decision support

Contact: kacem.chehdi@univ-rennes1.fr

Platform for video quality evaluation

- Expertise & media acquisition
- Subjective quality tests
- Dedicated equipments: 360° camera, 3D & VR monitors, 8k screen, etc.

contact: julien.heulot@insa-rennes.fr

Main experimental core facilities (4/4)

Hardware security of electronic systems

Hardware cybersecurity for electronic & embedded systems

Equipment

- Laser test facilities for fault injection and characterisation
- Electromagnetic eavesdroppping test benches (side-channel attacks)
- Electromagnetic aggression test setups

Special features

- Hardware attach analysis
- Analysis of electro-magnetic eavesdropping scenarios
- Investigation of novel side-channel attack scenarios
- Counter-measure studies

Contact: laurent.pichon@univ-rennes1.fr

Smart room for electronic security

Equipment

- Photovoltaic production
- Hybrid inverter (electrically insulated site)
- Electrical storage, programmable charging
- Infrastructures for hardware cyber-attacks

Special features

- Development and testing of control scenarios
- Study of attacks by auxiliary channels
- Study of electronic system failures

Contact: romain.bourdais@centralesupelec.fr

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They work with us

On average, IETR undertakes 75 new projects per year with public or private partners

The IETR has a large network of national and international partners, both industrial (R&D collaborations and services), institutional and academic

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IETR

Design of embedded systems group

Sébastien Pillement,
Olivier Pasquier,
Sébastien Le Nours,
Maria Méndez-Real

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ASIC Team

Organisation

Split over two sites: Rennes and Nantes

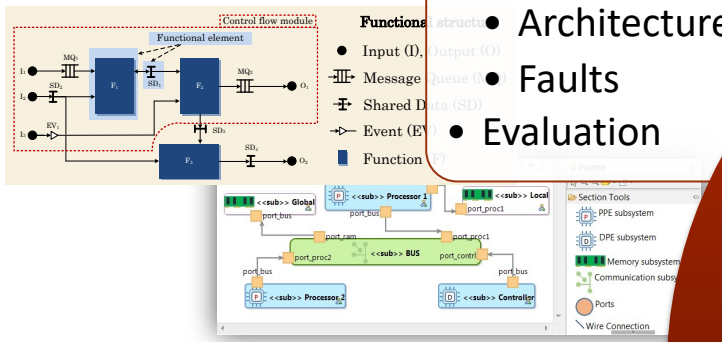
24 permanents, ~30 PhD/year (7 permanents and 10 PhD in Nantes)

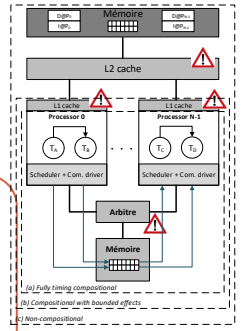
Focusing on low-power, reliable and high-performance systems

- Embedded AI
- Communications (5G, digital television, …)
- Power line communications
- Security and reliability

Design of connected systems

- Models
  - constraints
  - Architecture
  - Faults
- Evaluation





- Methodology
  - Exploration
    - Architecture
    - Performances

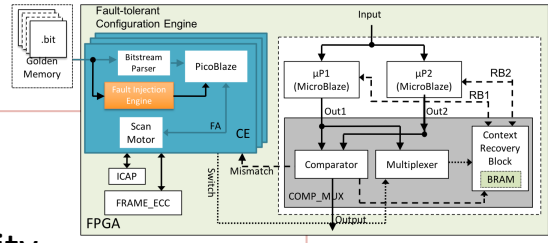
Performance evaluation

Method and tools

implementation and validation

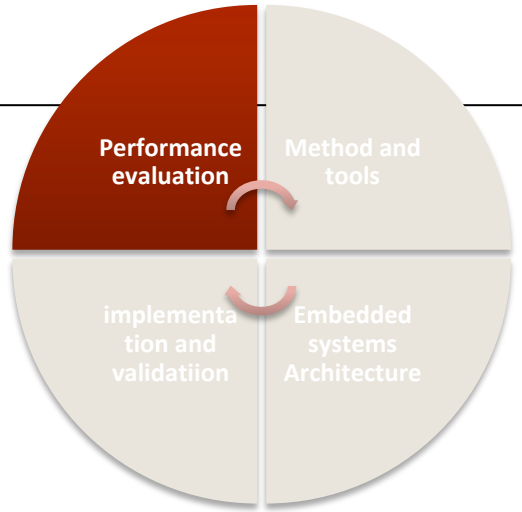
Embedded systems Architecture

- Platforms
- Performances
- Reliability
- Power



- Security
- Reliability mechanisms
- Reconfiguration management

Performance evaluation



Persons involved

- Khanh Le Son
- Tien-Thanh Nguyen
- Quentin Dariol
- Sébastien Le Nours
- Olivier Pasquier
- Sébastien Pillement

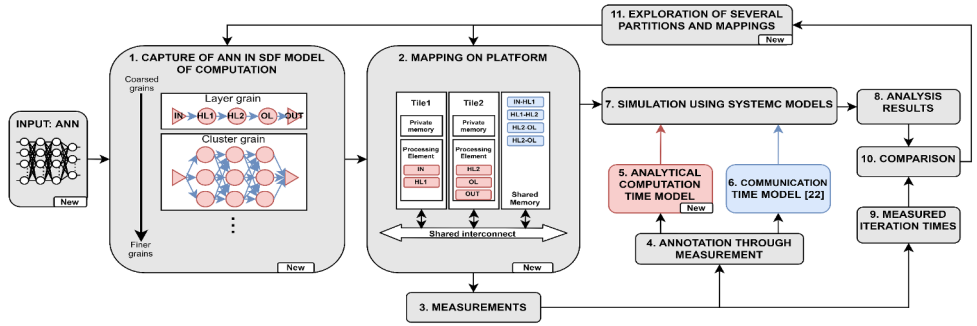
Main objectives

- Evaluation of performances (timing, power, reliability) in early design stages
- Considering safety during the design phases
- Design space exploration for security

PSSim4AI project

- Early performance prediction (timing and power) of neural network algorithms on multiprocessor platforms

- Established workflow
  - Extension of the previous workflow to address neural networks
  - Adoption of synchronous data-flow graphs with different levels of granularities
  - Proposal of an analytic computation model



- Experiment results
  - Multi-layer perceptron used in conjunction with the MNIST database
  - 2 neural network configurations studied for execution time prediction
  - Experiment on the fully-composable platform (Xilinx ZC702, UltraScale)
  - Accuracy: less than 1% error for a 784-32-16-10 network configuration allocated to 7 tiles

Holistar project

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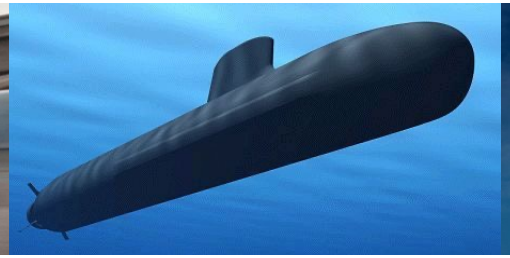
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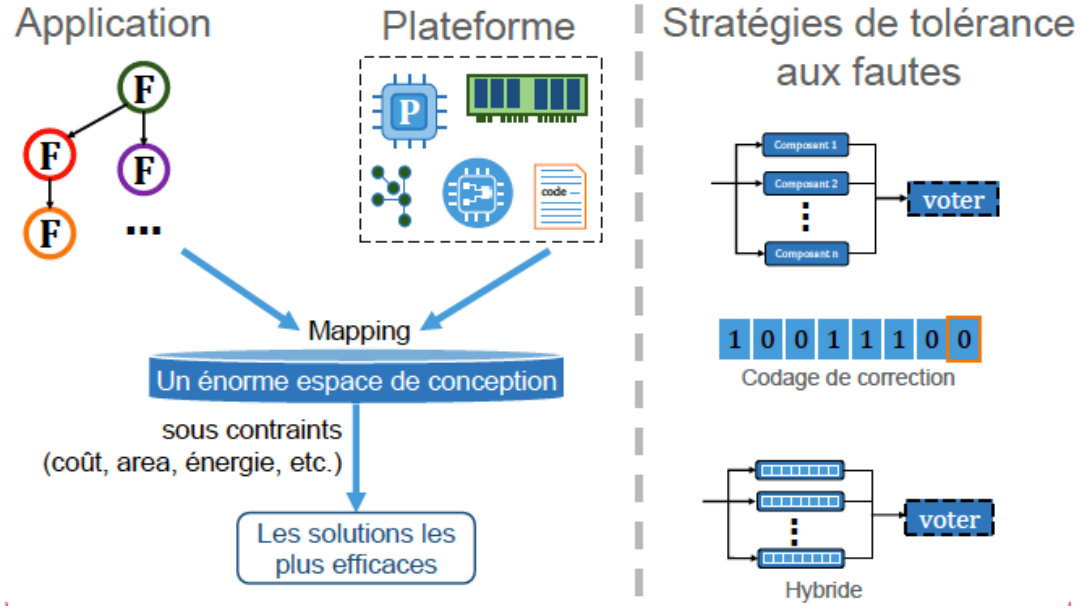
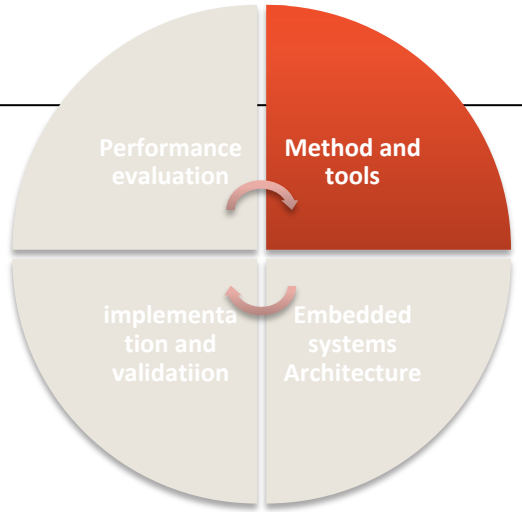
- Complex and critical applications
- Multi/many processors architectures
- Needs to explore the design space to find the best trade-off regarding reliability, costs and efficiency
  - Fault-tolerance strategies models
  - Reliability level evaluation



Method and tools



Persons involved

- Simei Yang,
- Dimitry Solet,
- Safouane Noubir
- Alexis Duhamel
- Sébastien Le Nours
- Sébastien Pillement
- Maria Mendez Réal

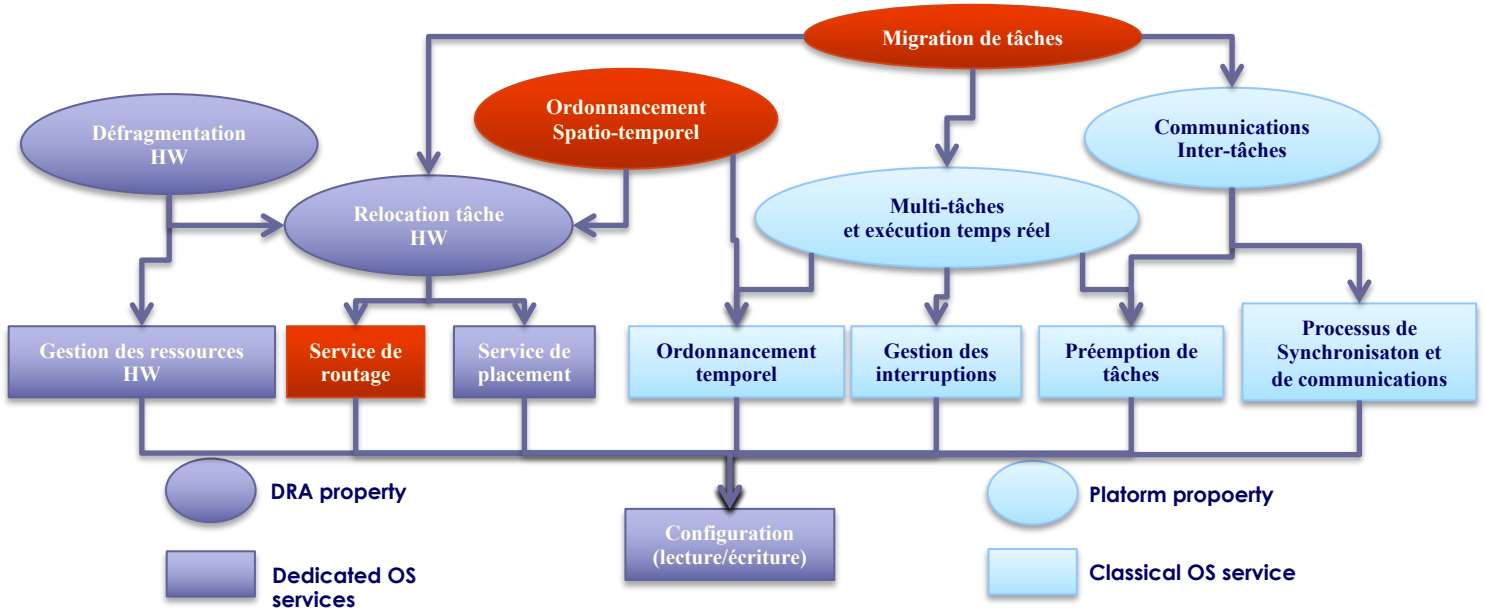
Main objectives

- Optimising the management of flexible platforms under timing, power consumption, reliability or security constraints
- Real-time hardware monitors for fault-detection
- Hardware security

Dynamic management of architectures

OS for reliability and flexible architectures

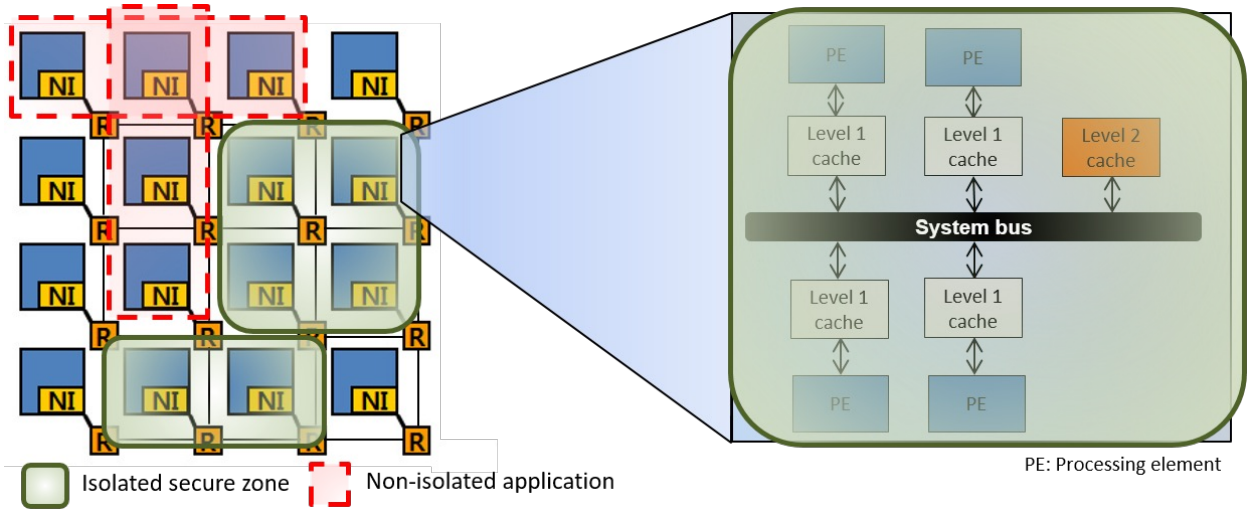
- Spatio-temporal scheduling in DRA for QoS
- Online verification of RTOS services
- Dynamic mapping and scheduling in multi-core platforms



Security in Multi and Many-Core Systems

HW and SW countermeasures

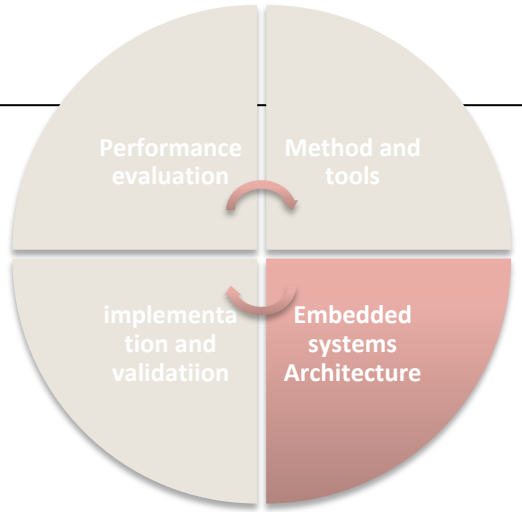
- Opportunities relying on dynamic resource management[1]
  => OS extended to support dynamic, adaptable secure zones
  ⇒ Impact of randomness and routing strategies against NoC timing attacks



⇒ Instruction accurate Imperas OVP +
⇒ Cycle accurate SoCLib simulation tools

imperas
SoC lib
OVP Open Virtual Platforms

Embedded systems architecture



Persons involved

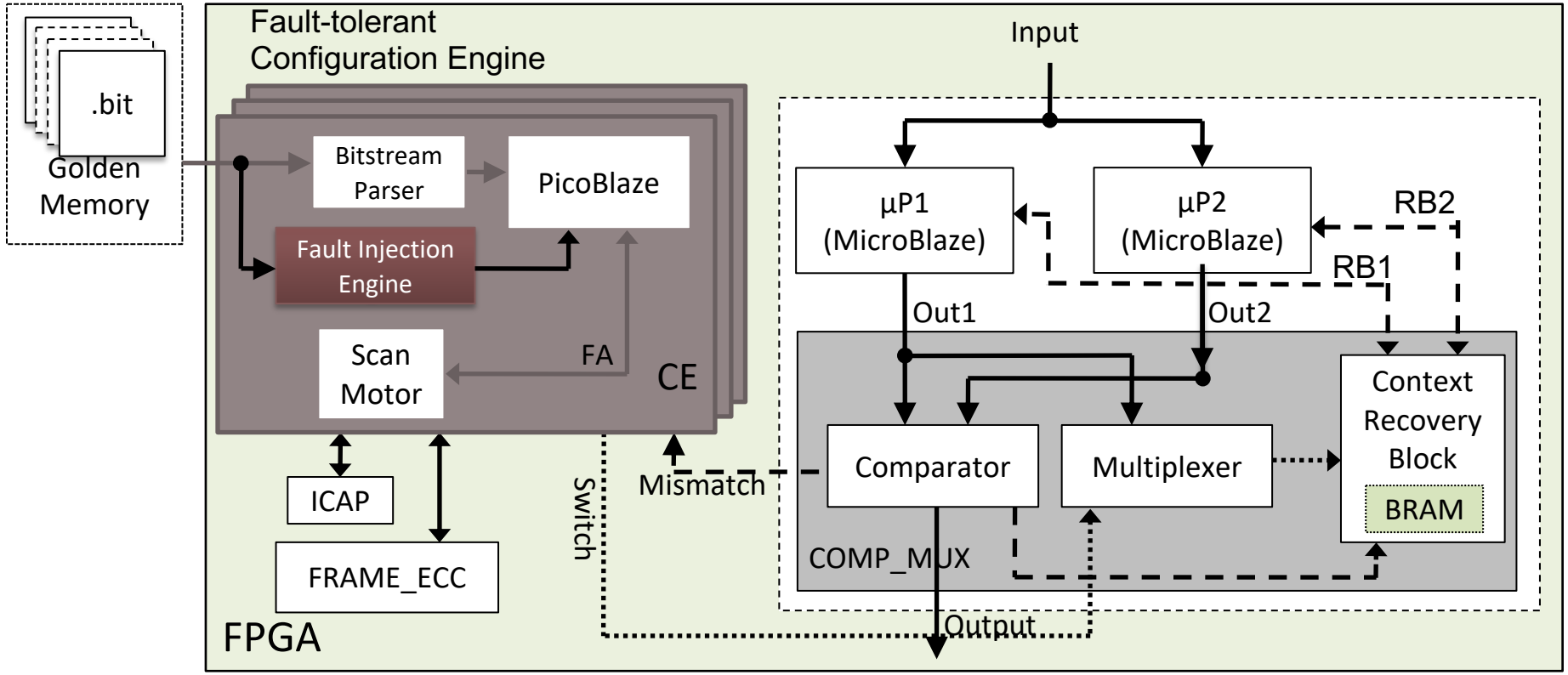
- Tien-Tanh Nguyen
- Sylvain Takougang
- Juliette Pottier
- Amine Zhiri
- Maria Méndez Real
- Sébastien Pillement

Main objectives

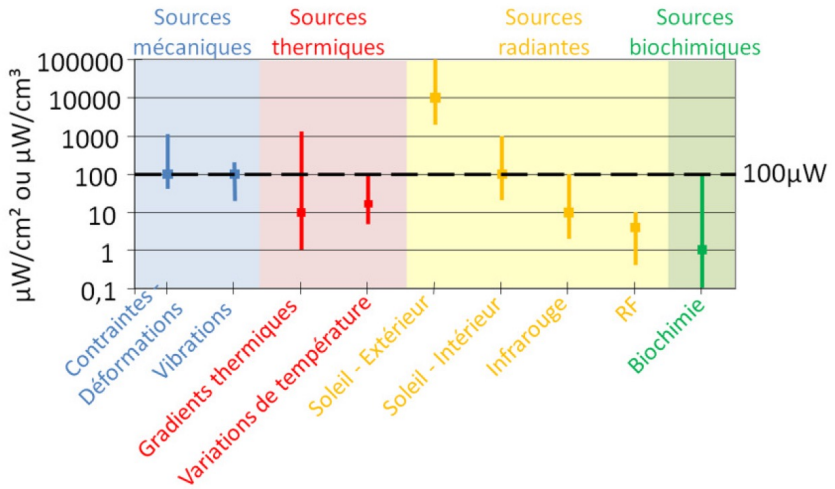
- Design of architecture increasing security, performance or reliability
- Ultra Low-power

Architecture for reliability

Enhanced Lockstep



Ultra Low-power architecture



The NOP project

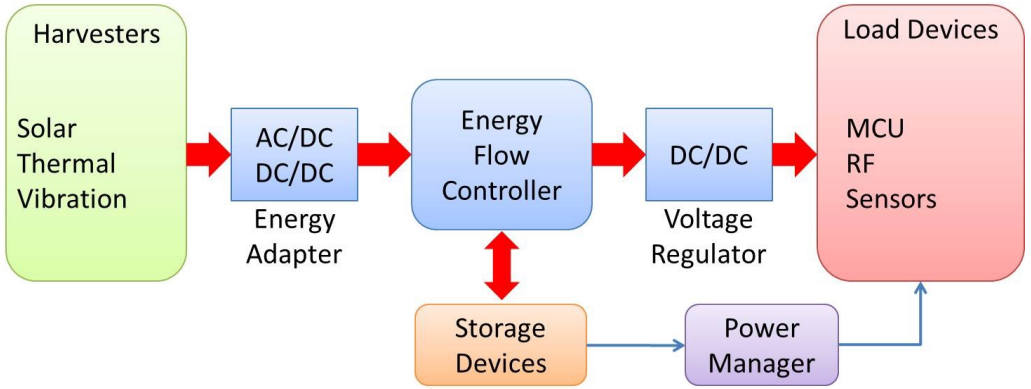
Pervasive deployment of smart things, many of which cannot be connected to the grid, e.g., precision agriculture, or wildlife monitoring.

Push toward bringing computations closer to data sources to improve privacy, latency, or energy efficiency (compute more, transmit less)

Objective: reach energy autonomy!

- Based on energy harvesting

- Using NVM technology
- Holistic approach of **normally-off platform**
  - Compilation, Operating-system
  - Architecture, Communications



Architecture for security

The ANR SecV project

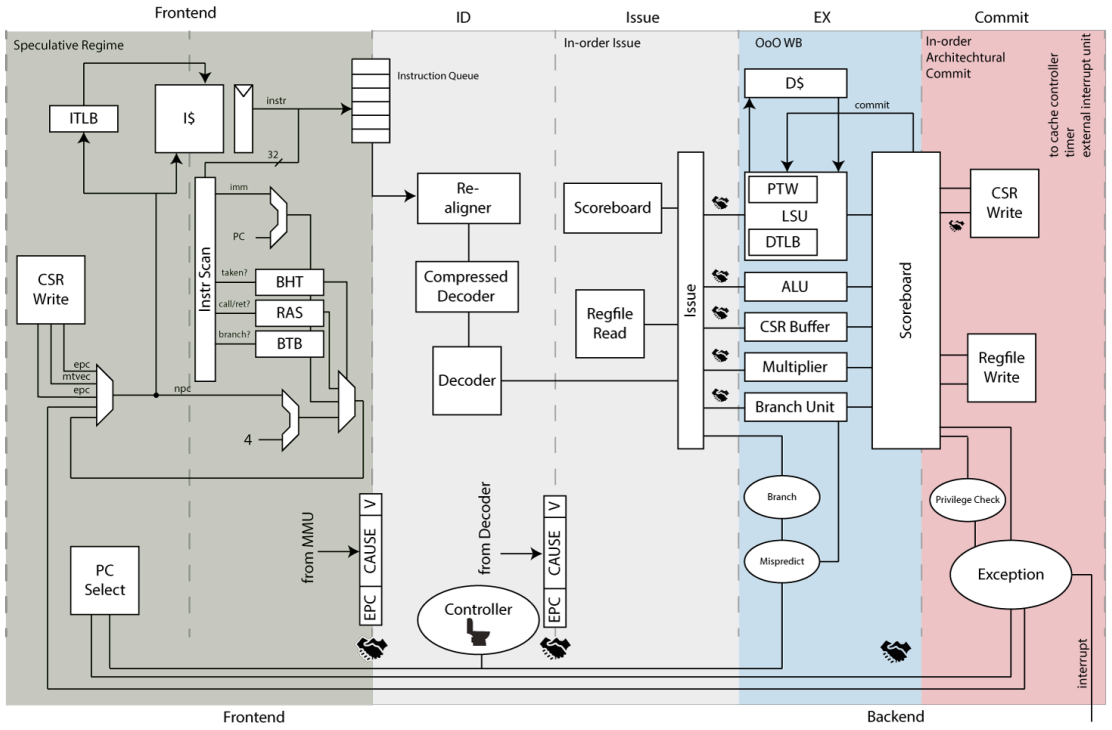
Integration of a dynamic code transformation unit covering 4 of the 5 NIST functions of cybersecurity, in particular via **monitoring** (identify, detect), **obfuscation** (protect), and **dynamic adaptation** (reacting).

Main challenges

- Secure and high performance hardware structure
- Dynamic security management
- Innovative approach to security by dynamically adapting the operations of the micro-architecture

Innovations

- Dynamic instruction decoding unit
- Configurable memory management policies
- Flow and instruction control block



Dedicated architectures, Embedded AI

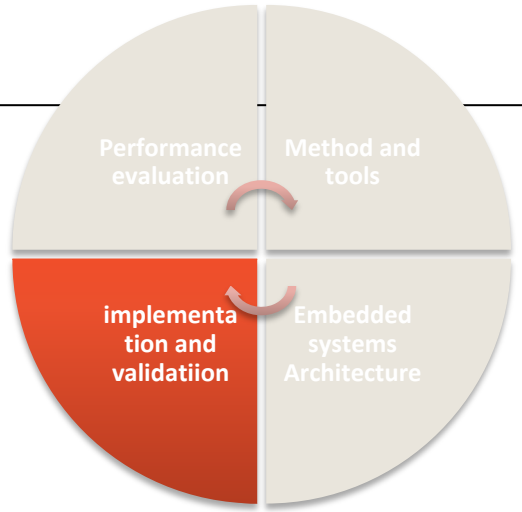
The PEPR AI, starting in late 2023

Large structuring project of 5,4M€.

Support for PhD, equipments and travelling expenses

- #1 Flexible ultra low power architecture supporting different artificial intelligence algorithms in the Internet of Things context
- #2 Monitoring Federated Learning systems with explanations
- #3 In-network computing for decentralised federated learning
- #4 PhD: Hybrid management approach for context-aware adaptation of neural network architectures
- #5 PhD: Online verification methods for safe and explainable embedded AI

Implementation and validation



Persons involved

- Mustafa Ibrahim
- Marc Brunet

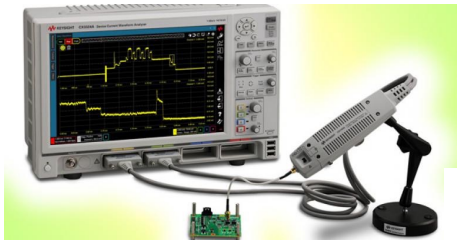
Development platforms

- Xilinx UltraScale+ EG, ZedBoard, Microsemi,
- ALTERA FPGAs board supporting OpenCL
- ARM, ATMEL, Exynos (plus Arduino, Raspberry, stamp)
- High performance servers

Development environments

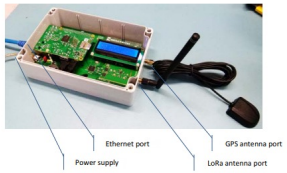
- Synopsys, Xilinx SDSoC environment (HLS, C/C++/OpenCL, …), Libero
- Mentor QUESTA
- ATMEL Studio, INTEL Cofluent

The IoT platform



- Consumption measurement bench:
  - High performance power supply
  - High performance oscilloscope
  - High precision current analyzer
- Experimentation platform:
  - USRP Basics
  - Heterogeneous computing nodes (ATMEL SAMD21, Raspberry, Arduino, PanStamp, ST Nucleo, etc.) (about a hundred currently)
  - Communications shield LorA, WiFi, Bluetooth, Zigbee, PanStamp

- Radiation and radio characterization
  - Centimetric anechoic chamber
  - 20GHz Vector Network Analyzers:
  - 26GHz spectrum and modulation analyzer
  - 6GHz Vector Signal Generator:



- Security
  - AVR ChipWhisperer SDK, hardsploit

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