IRISA

INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

INRIA

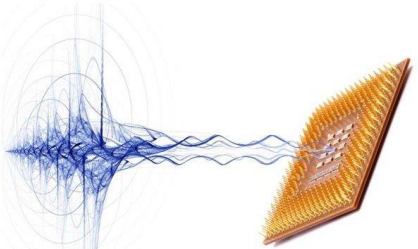
centre de recherche RENNES - BRETAGNE ATLANTIQUE

IRISA - CAIRN team

Research activities related to power reduction in WSN

Olivier Sentieys

IRISA/INRIA, University of Rennes 1
ENSSAT Lannion
sentieys@irisa.fr



ENS CACHAN BRETAGNE

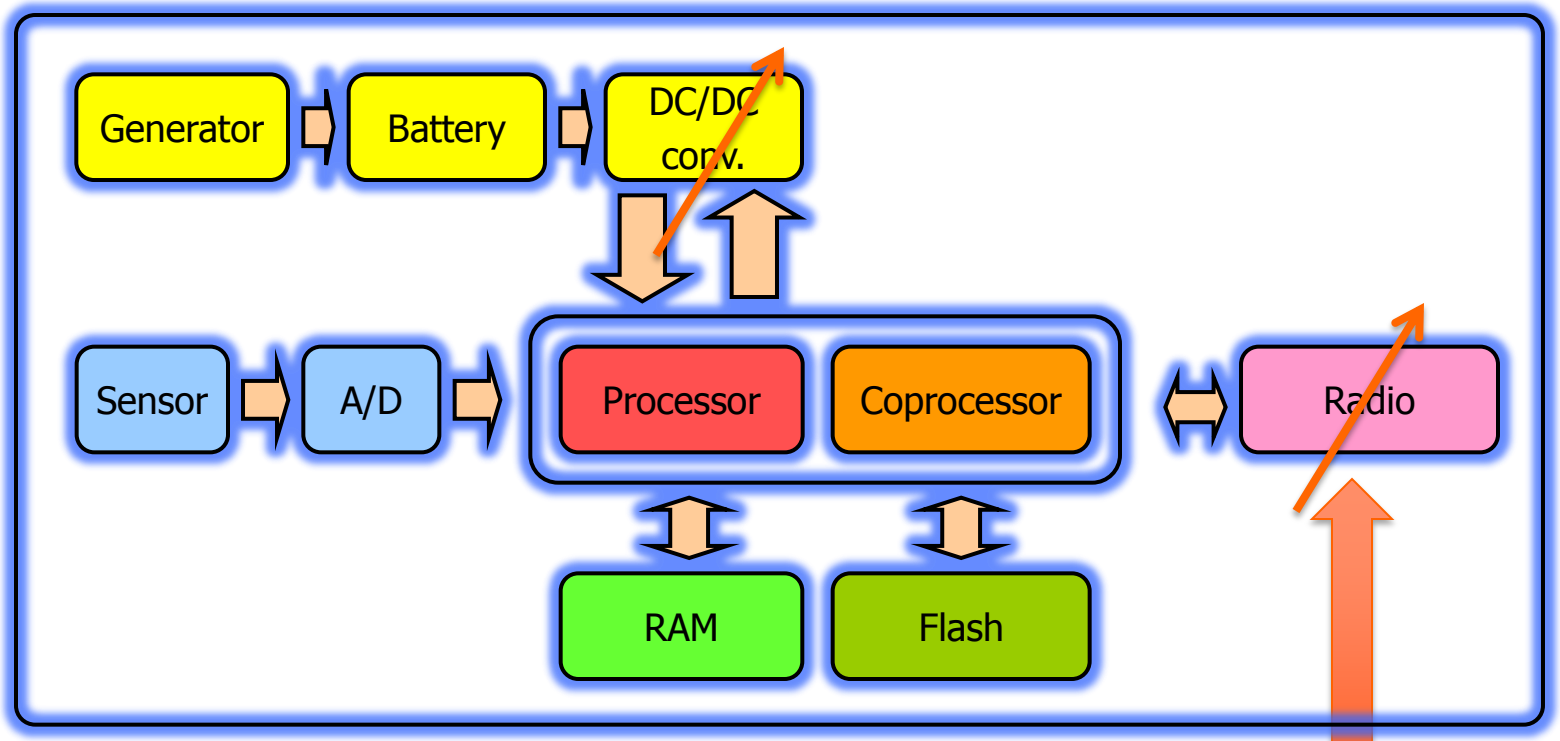
UNIVERSITÉ DE RENNES 1

IRISA/CAIRN team at a glance

- IRISA: Research Institute in Computer Science and Random Systems
  - UMR CNRS 6074, INRIA Rennes research center
  - Nearly 600 people, 30 research teams

- CAIRN team
  - ~40 people
  - Associated to UR1, ENS Cachan, INRIA, CNRS
  - Rennes (Beaulieu) and Lannion (ENSSAT)
  - Domain-Specific and Reconfigurable System-on-Chip (architectures, tools, algorithms)
  - Wireless and Video Communications
    - including Wireless Sensor Networks

Generic architecture of a wireless node

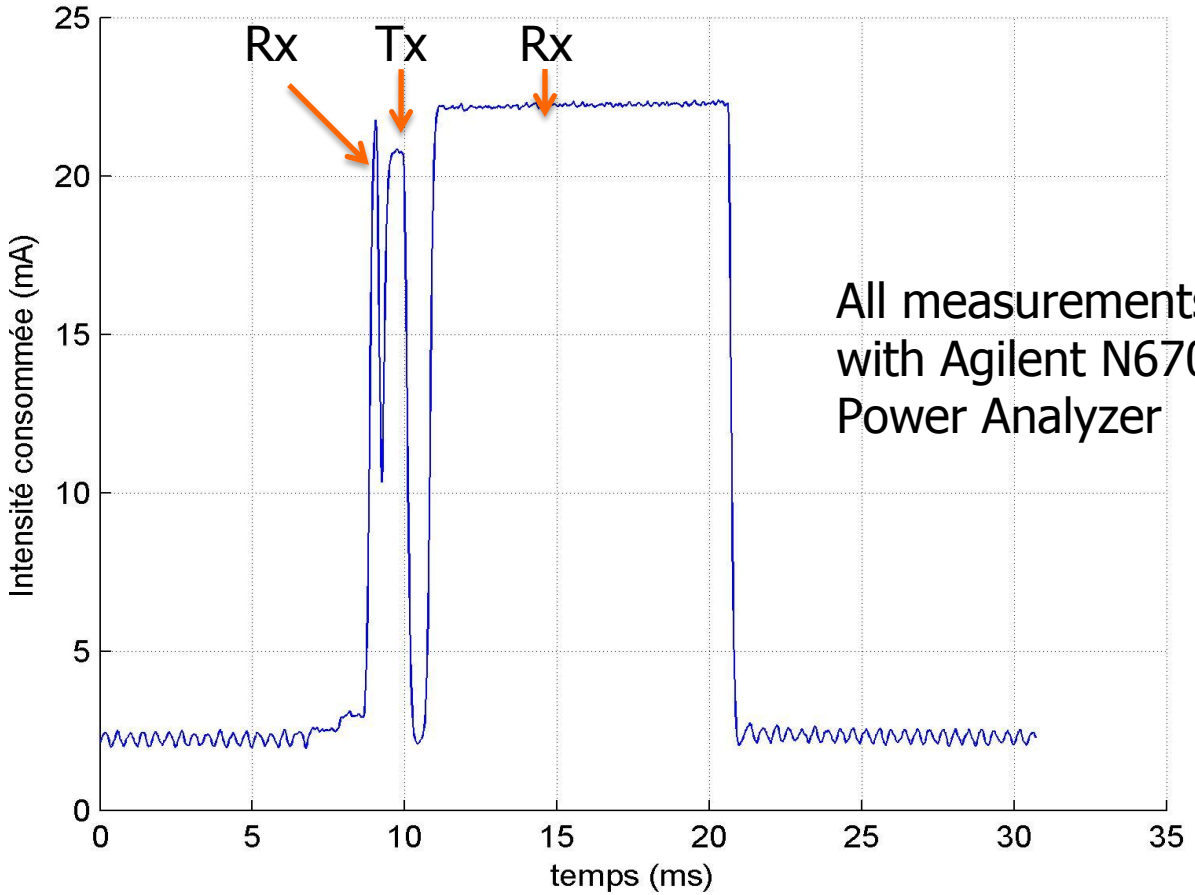


- Typical Power Consumption
  - o **Radio** in Rx/Tx: 30-70mW
  - o Processor/Coprocessor: 5-10mW

85%

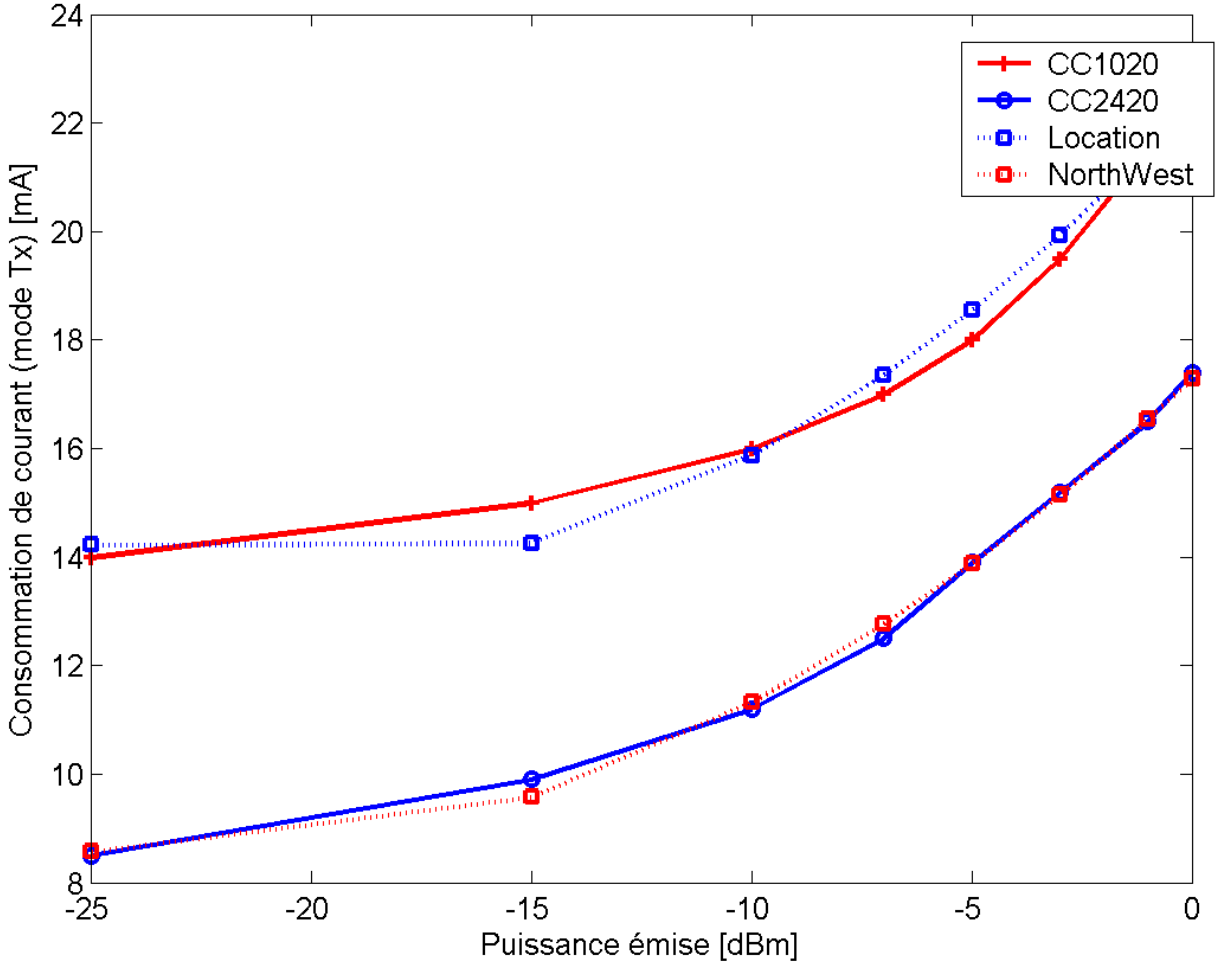
Power Measurements on PowWow HW

- Wake-up and channel sensing



All measurements realized with Agilent N6705A DC Power Analyzer

Chipcon Radio Tranceivers



Research objectives

- *How to design and optimize an energy-efficient software and hardware platform for wireless sensor networks ?*
- (1) Decrease transmission (Tx) power
- (2) Optimize radio activity and MAC
- (3) Power optimization of the hardware
- (4) Optimize software stack

Research Themes

- Node architecture
  - HW Platform
  - SW Stack
  - Platform and network simulation
- Algorithmic-Level Energy optimization
  - *Question is "How much (signal) processing can I add to reduce the radio Tx/Rx power in order to optimize the global energy (or autonomy) of the network ?"*
  - Cross-layer (MAC/LINK)
  - MIMO, Cooperation, Relaying
- Architectural and Circuit Level Optimization
  - FPGA co-processing
  - Specialized SoC design

PowWow HW Platform (2008)

- Modular board design
  - Mother board MSP430
  - Daughter board for
    - CC2420
    - FPGA
    - Sensors
    - DVFS

- Microprocessor
  - TI MSP430
  - Fclk: 5 MHz
  - Valim: 2.7 - 3.6 V
  - RAM/Flash: 5 Ko/55 Ko
  - 500uA/MHz@3V
  - 330uA/MHz@2.2V
  - Low Power Modes
    - 50uA, 11uA, 1.1uA, 0.1uA

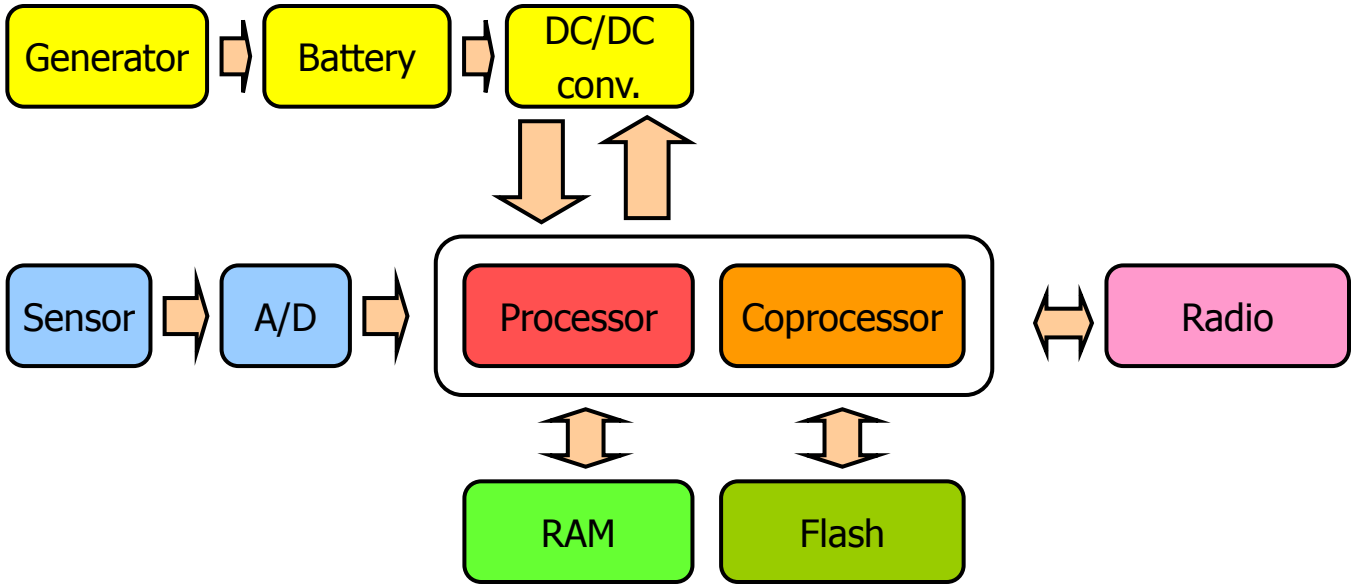
- Radio transceiver
  - TI CC2420
  - 802.15.4/ZigBee compliant
  - Frequency: 2.4 GHz
  - Sensitivity: -95 dBm
  - Max rate: 250 Kbits/s
  - PTx: 25 dBm to 0 dBm
  - Tx Power 17.5mA at 0 dBm
  - Rx Power 18.8mA
  - Idle/Down 426uA/20uA

PowWow SW Stack

- Open source software developed at IRISA/CAIRN
  - http://powwow.gforge.inria.fr (june 2009)
- Based on Protothread library and Contiki
  - Event-driven programming
  - Flexibility, compactness of code
- HAL, PHY, LINK, MAC, NETW, API
  - FEC/ARQ, geographical routing, positioning, Tx power manag.
  - Modes: broadcast, flooding, direct/multi-hop with/without ACK
  - Configurable packet structure
- Memory efficiency
  - 6 Kbytes (HAL-NETW) + 5 Kbytes (APPLICATION)
- Analytical power estimation based on software profiling and power measurements of a set of scenarios
  - Power/10 w.r.t. ZigBee/802.15.4
- Over-the-air re-programmation (and reconfiguration)

HW Platform Energy Optimization

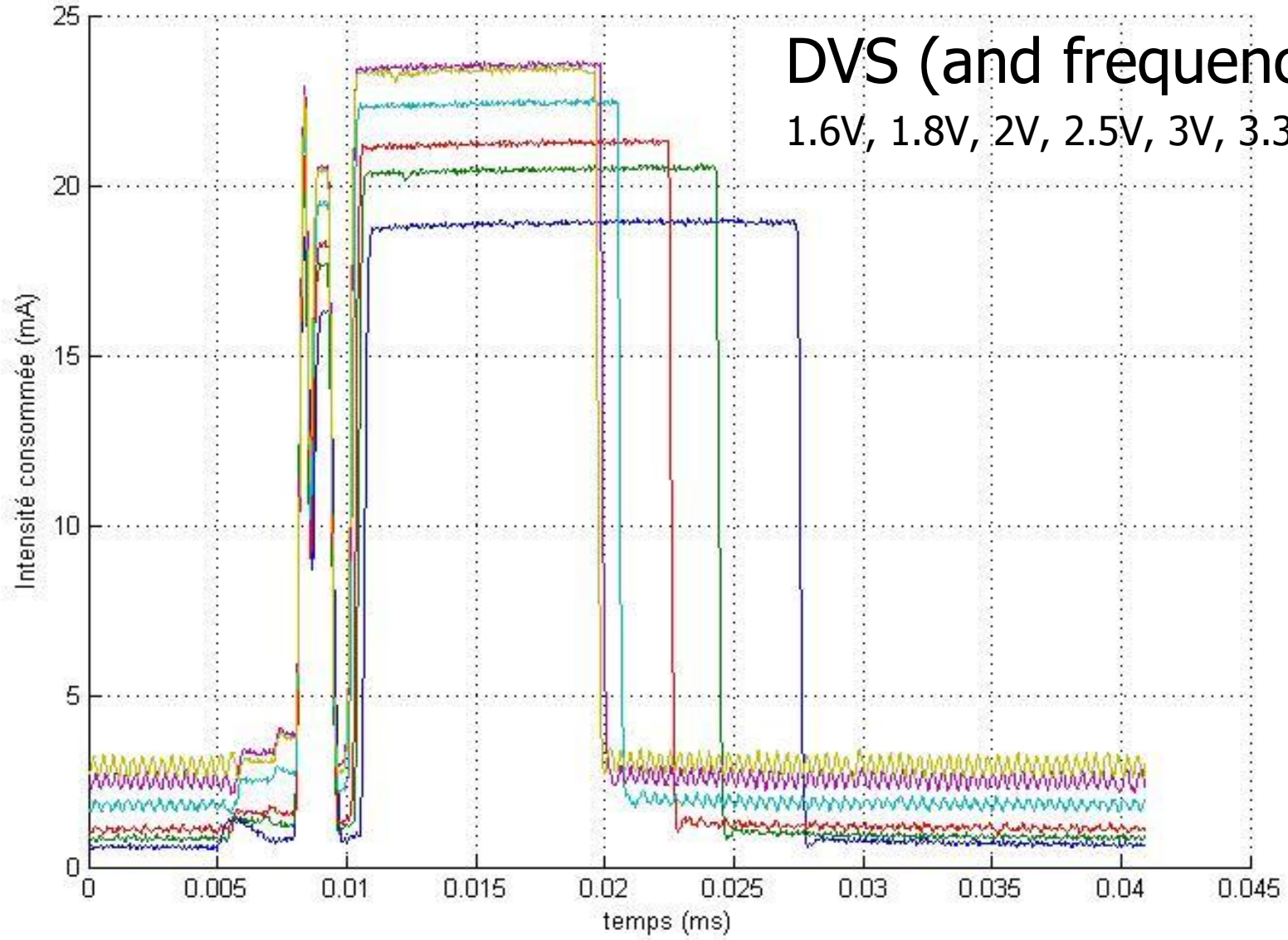
- (1) Co-processing
- (2) Dynamic Voltage Scaling
- (3) Power Gating, Dedicated SoC
  - … 100-1000x power reduction



Coprocessing with Low Power FPGA

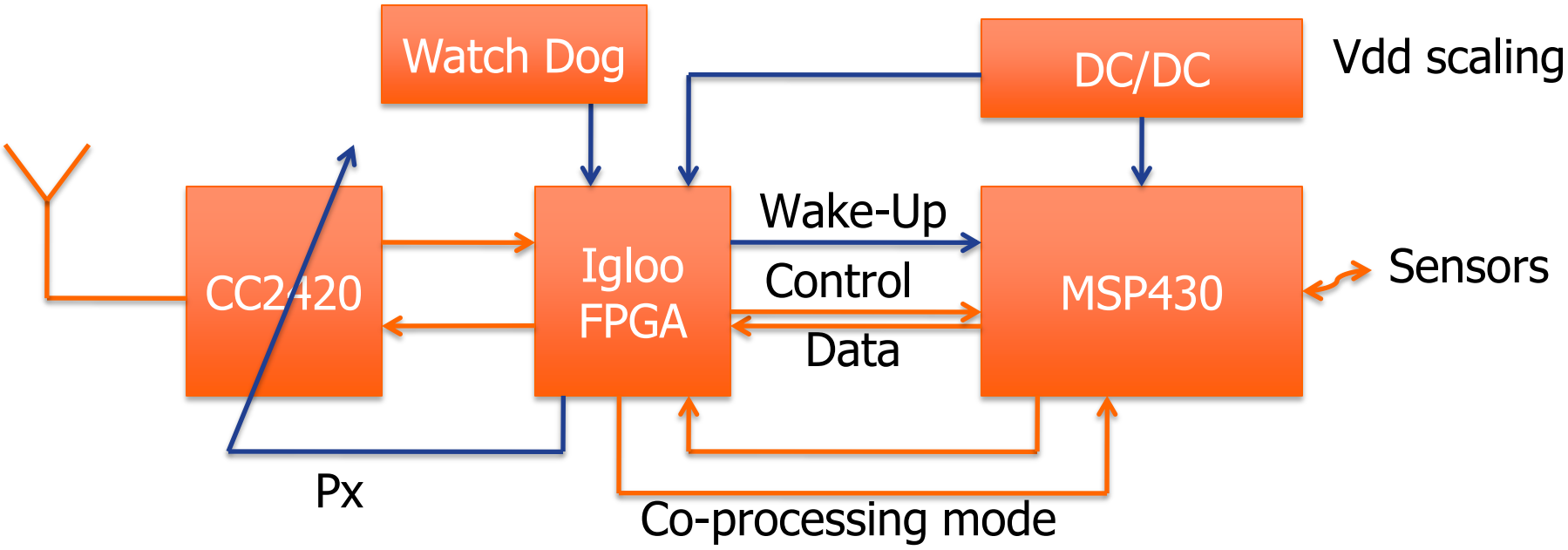
- Actel Igloo FPGA
  - AGL125, 130nm, 125kgates
  - 32kbits RAM, 1 kbits Flash, PLL
  - 1.2V (0-1.65V)
  - 2.2uW/16uW/1-30mW (sleep/freeze/run)
  - Implemented Viterbi for link layer: 5mW
- FPGA power efficiency on CRC32
  - CRC32 on MSP430
    - E_{msp} = 150µs x 20mW = 3µJ (at 8MHz)
  - CRC32 on Actel Igloo AGL125
    - 125k gates, 36kbits RAM,
    - E_{igloo} = 0,8µs x 5mW = 0,004µJ (at 20MHz, including I/O)
    - Energy saving = 150/0,8x20/4 = **750**

Dynamic Voltage Scaling



PowWow V2 (2009)

- FPGA for low-level processing and hardware acceleration
- Voltage scaling
- Wake-up for ultra-low-power modes



Projects

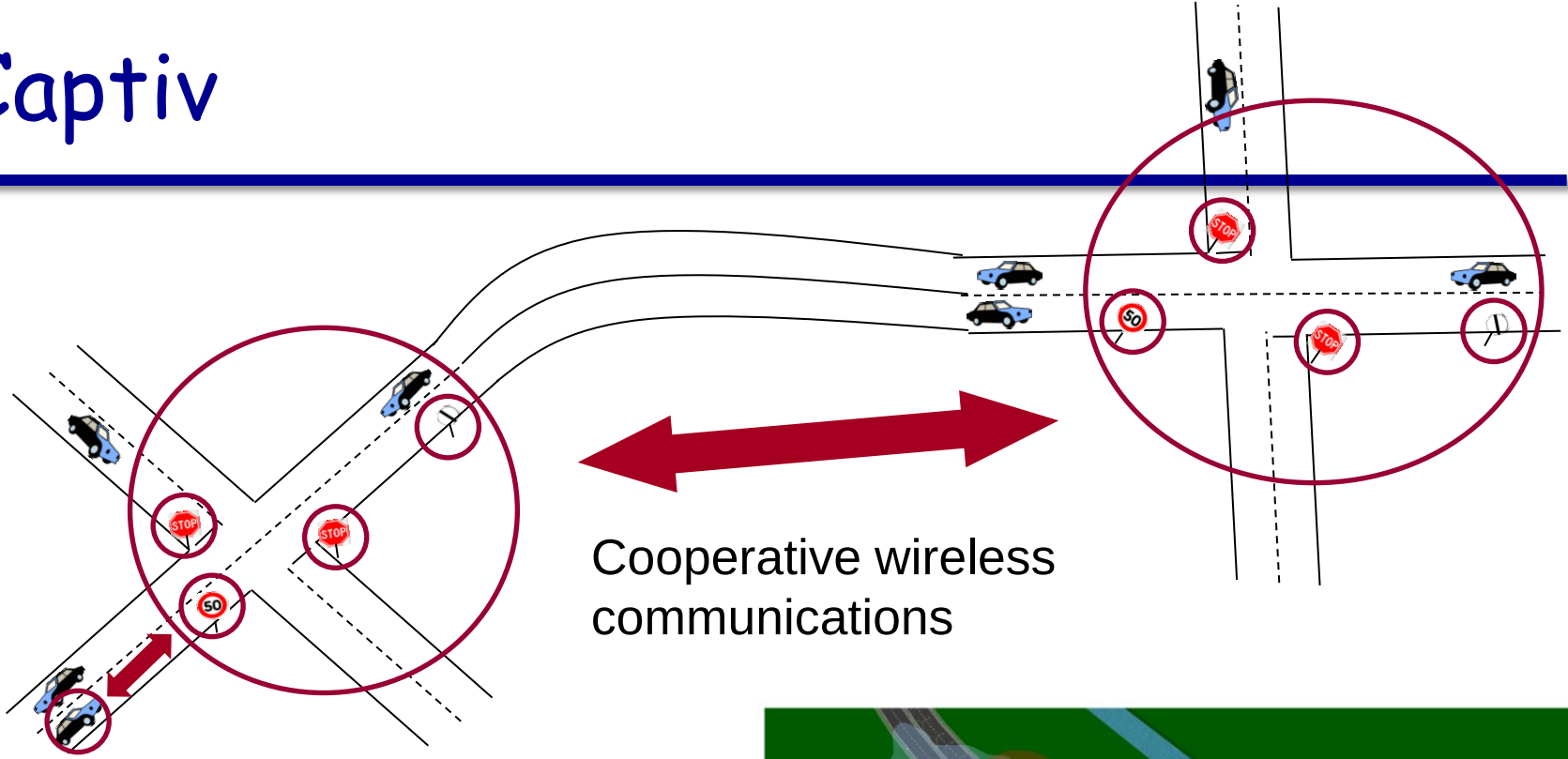
- CAPTIV (completed)
- ANR SVP (completed)

- ITEA2 GEODES (2008-2011)

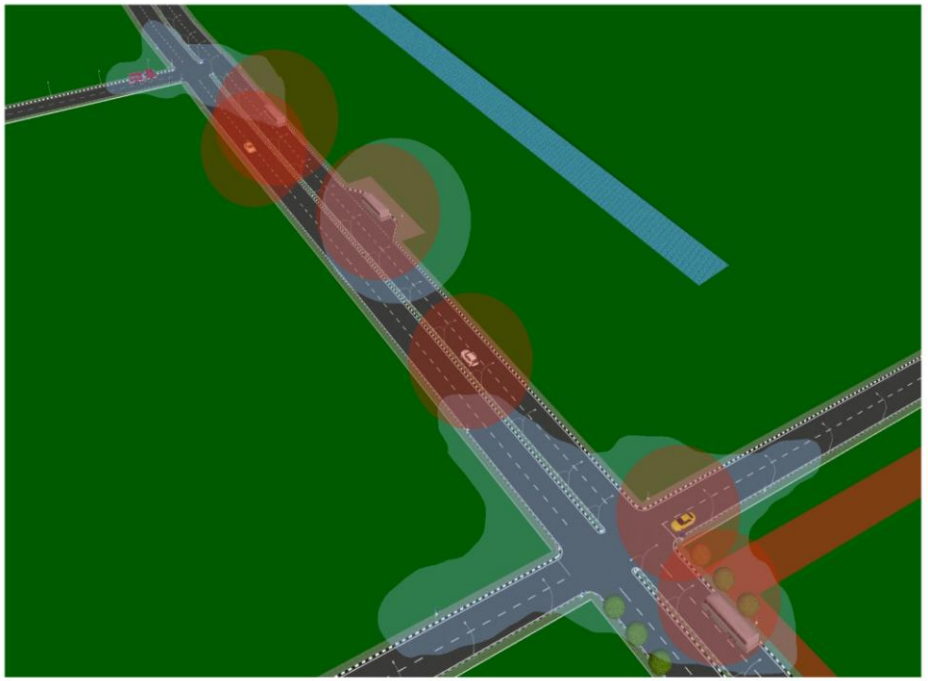
- TRANSECT (pôle ID4CAR)
- Catrene HERTZ
- CPER Perecap

- Collaborations
  - Telecom Bretagne, LEAT, INRIA (Pops, Swing)
  - Laval U. (Ca), T.U. Vienna (At)
  - Thales, Thomson, Veolia, Magneti Marelli
  - Philips, Infineon
  - Sensaris, Aphycare, Kerlink, BeNomad, Eca-Faros

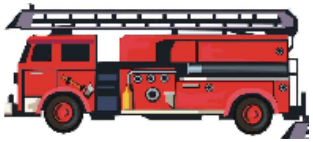
Captiv



Cooperative wireless communications



ITEA2 Geodes: fire-fighters



- Indoor network
  - Temperature monitoring, smoke detection, motion detection
  - Camera nodes
- Mobile nodes (fire-fighter)
  - Health monitoring, camera, etc.
  - Connected with indoor network

People involved

- Olivier Berder, François Charot, Steven Derrien, Patrice Quinton, Olivier Sentieys
- Thomas Anger, Jérôme Astier, Arnaud Carer
- Duc Nguyen, Adeel Pasha, Vinh Tran, 2 new PhD thesis in 2009

Questions ?