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Master de Recherche – Master of Research

Title: Implementation and Power Estimation of some basic Functions of WSN Applications on a Low-Power FPGA Accelerator

Keywords and skills: Wireless Sensor Networks, embedded software for microcontroller, C, FPGA design, VHDL, Matlab, radio transceiver.

Laboratory: IRISA/INRIA –CAIRN project-team (Lannion)
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Wireless Sensor Networks (WSN) have garnered significant attention in recent years. WSNs consist in a set of spatially distributed autonomous devices, where the energy consumption is the most important criterion. They can be applied for wide variety of applications: environmental monitoring, health, human behavior study, smart road and vehicles, smart homes, security, agriculture, etc..
To maximize the lifetime of the network, a power-efficient implementation of algorithms used in different protocol layers is mandatory. Classically based on low-power microcontrollers, the sensor nodes, although limited in size and energy, may include low-energy-consumption FPGA and dedicated ASIC.

The goal of this Master's Thesis is to contribute to reducing the power of sensor nodes through a comparative study of several hardware (FPGA or VLSI coprocessors) and software (processor) targets, and a methodological approach for the software/hardware partitioning. More precisely, the objective is to evaluate the potential power gain of implementing some parts of the protocol and application layers of a WSN node on a low-power FPGA with regards to its classical software implementation on a microcontroller. Previous works on error correcting codes have shown that gains of more than a hundred can be obtained for an FPGA implementation compared to a software implementation on the most energy efficient microcontrollers.
Functions that must be implemented and characterized are typical functions of sensor networks in the different protocol layers. Emphasis will initially characterize simple functions of medium access layer (MAC) [1], error correcting codes (link layer) and simple geographical routing. Some advanced routing and positioning algorithms suited to the context of mobile sensors will also be investigated as well as cooperative techniques [2].
The possibility to dynamically adjust the voltage of the sensor node (DVS for Dynamic Voltage Scaling) is a very promising approach for energy efficiency. As part of this work, it would be interesting to characterize the energy at different voltages for some of the functions mentioned above.

The work will be based on the WSN platform developed at the IRISA Lab. in the Cairn team: PowWow. Cairn's node is based on the MSP430 microcontroller, the CC2420 radio transceiver and a very low-power FPGA from Actel (Igloo). PowWow software includes the different layers of WSN (PHY, LLC, MAC, NTW, APP) and is developed in C under the contiki protothreads library.
The candidate will mainly focus on the design of hardware accelerators on the FPGA in VHDL, but may also include some embedded software development in C. Interface between the radio transceiver and the FPGA has also to be developed.

[1] O. Sentieys, O. Berder, P. Quémerais and M. Cartron, "Wake-up Interval Optimization fo Sensor Networks with Rendez-vous Schemes", *Proceedings of the Workshop on Design and Architectures for Signal and Image Processing* (DASIP'07), Grenoble, France, November 2007.
[2] T. Nguyen, O. Berder, and O. Sentieys, "Cooperative MIMO schemes optimal selection for wireless sensor networks," *IEEE 65th Vehicular Technology Conference, VTC-Spring*, pp. 85 – 89, 2007.