Power Estimation using the Hogthrob Prototype Platform

M.Sc. Thesis by Martin Leopold

Hogthrob

Sensor network for sow monitoring

This thesis is placed in the context of the Hogthrob project, a 3 year research project with partners from:
- DTU
- KVL
- DIKU

The goal is to build a sensor network for sow monitoring.

Sow monitoring today:
- RF-ID tags
- Identification for feeding-station
- Estrus detection (boar visit)

Hogthrob:
- Replace ear tags with sensor node
- Define a sensor node that fills the requirements

Approach:
- Design a prototype to explore design space

Key challenges:
- How to detect estrus?
- How to evaluate design choices?

Goals

Sensor network for sow monitoring
- Functionality
- Tracking
- Detection of Heat Period
- Low cost (< 1 EUR)
- Low energy (2 years)

The real Hogthrob

Challenges

1. Is there a sensor node that fits the req.?
   - The current generation of sensor nodes is a "one-size-fits-all". This strategy has drawbacks:
     - The hardware is fixed
     - The price is too high
     - The performance is limited (formfactor, power).
   - We need a sensor node built for this application

2. How do we meet the requirements of the app.?
   - During the design of our sensor node we need a systematic approach to evaluate design choices.
   - In particular, how do we evaluate the power consumption of a sensor node as a part of the design process (before it is built)?

Prototype Platform: Hogthrob V0

The prototype platform (hogthrob V0) is built as part of the research project. Through my thesis work I took part in designing this platform.

Hogthrob V0 is not a sensor node, and does not share the properties of a sensor node (price, energy, etc.)

It features an FPGA and a simple microcontroller. The microcontroller functions as an external timer and A/D converter to the FPGA. Also it will serve as the main processor in the beginning and gradually software will be moved to a microprocessor in the FPGA.
- FPGA: Xilinx Spartan3
- MCU: Atmel ATMega128
- Radio: Nordic VLSI nRF2401
- Sensors:
  - Analog Devices ADXL320
  - ST Micro: ST LIS3LD02S
  - Nimbus processor core (ATMega compatible)

Power estimation strategies

1. Direct measurement:
   - Input: real
   - Program: real

2. Simulation:
   - Input: synthetic
   - Program: synthetic, derived, real

New approach

Hybrid using the Hogthrob V0 platform
- Use hardware simulation (FPGA)

What’s new?
- Allows exploring every aspect of the design space
- Simulation in situ

Proof of concept

I have implemented a proof of concept of this new approach:
1. The Nimbus core is placed in the FPGA
2. An activity trace is captured
3. Using a power model this is mapped to the power consumption that could be expected if this was implemented as a chip

Field experiments

To get a feel of the kind of data that can be expected, a field experiment was carried out.
Sensor nodes were attached to 5 sows. The node collected data for 30 days in a stable. 4 cameras were installed to record the movement of the sows.

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