Low power sensor nodes design: a cross-layer approach and prototyping

Jean-François Frigon
Yvon Savaria
École Polytechnique de Montréal
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Approach

- To achieve truly low power wireless sensor nodes a **cross-layer approach involving both novel communication protocols and hardware design** is required.

- **Prototyping** is required to demonstrate the validity of these concepts.

- At École Polytechnique de Montréal, we are joining our expertise from different fields to achieve these goals.
Communication systems

- Take advantage of recent advances in wireless communication to reduce transmit power:
  - Reconfigurable antennas
  - Cooperative networks
  - Opportunistic routing and mesh networking
  - Etc.

- Design protocols which can take advantage of low power hardware design to decrease overall power consumption
Reconfigurable antenna concept

- Use antenna elements with real-time electronically controllable radiation patterns
- Adjust the radiation patterns to improve the system performance
Antennas

- Possible type for reconfigurable antennas which can dynamically change some of their radiation properties:
  - Switched parasitic antennas (MEMs or pin diode)
  - CRLH leaky wave antenna

- Requirements:
  - Fast electronically controllable full-space continuous scanning and beamshaping
  - Low cost
  - Small foot print
  - Easy integration with other IC components
Reconfigurable antenna benefits

- Improved QoS in an **unpredictable** wireless environment
- Dynamically look for the best radiation patterns:
  - Higher data rate
  - Power gain
  - Reliable communication

Achieve same performance with significant transmit power reduction

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2x2 MIMO - 802.11n Model B - 12 Cells LWA

Spectral Efficiency (bps/Hz)

Noise (dB)

- **DRPD**
  - Detectivity RF power: **7dB** ↓
  - Range: **2.5x** ↑
  - Coverage: **5x** ↑
  - Battery: **5x** ↓
Cooperative networks

- Concept: use multiple single antenna terminals to create a virtual transmit antenna array
- Benefits from instantaneous better channel from other users
Achieve same performance with significant transmit power reduction
Long term goals

- Select, adapt, design and implement suitable communication protocols
- Develop efficient and adaptable processing structures
- Develop clocking and synchronization strategies that enable delivering the required functionality using the minimum energy
- Low voltage energy-efficient digital library: requirements and best use
- Synergistic integration of system to circuit optimization
Objectives

- Power efficiency of sensor-actuator network motes in the context of bioscience applications
- Our goal is to maximize their operational life while maintaining adequate sensing and actuating ability and computing power

Five objectives:

- Defining and analyzing the application requirements (communication protocols, security mechanisms and control mechanisms)
- Define effective processing and control structures
- Investigate effective synchronization mechanisms
- Explore how voltage-scaled digital cells can improve energy efficiency
- Integrate the first four in a synergetic way looking for compatible solutions
Prototyping

1\textsuperscript{st} phase: CMC Compact Wireless Microsystem platform
Built around the CC2430 TI Zigbee SoC
Evaluation of platform ability to support basic low power cross-layer designs:
- Power aware MAC and link layer protocols
- Opportunistic routing and mesh networking
- Cooperative networking
- Voltage and frequency scaling
Use the developed platform to validate proposed solutions

E.g.

- power consumption models
- fine-grained voltage scaling scheme

Modifying the platform to suite those needs would be very valuable
Future Research

- Propose modifications to platform:
  - Enabling lower power consumption
  - Support wireless body area networks for biomedical applications
Other needs?

- Collaboration with other research teams:
  - Discussion to understand your needs and requirements
  - Propose modifications that will make this platform useful in your research projects
  - Can we make this platform more versatile for research?