Green Systems: From Platform to OS

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Many shades of Green…

Sensing Application Requirements

- Resource needs of wireless sensor nodes have high dynamic range
  - Sensing tasks require from $10^{-3}$ to $10^3$ MIPS even on the same node
  - Communication requirements across nodes range from $10^{-1}$ to $10^3$ kbps

- No single processor or radio spans this range efficiently
  - A mix of complementary components is better suited
  - Components arranged in a staged or tiered fashion enable selective activation
ASPIRE Staged System

- Stages of complementary components provide high dynamic range of capabilities
  - Analog Signal Processing
  - Low Power Microcontroller
  - High Efficiency Digital Signal Processing
  - Server Side Processing
  - Cross Stage Interaction

- Staged design raises interesting research issues
  - Optimal stage activation policies based on ‘event context’
  - Interconnect architectures for ‘context transfer’ across stages
  - Lowering transition times between stages exchanging ‘context control’
  - Energy aware resource management at OS level
  - Lowering quiescent power consumption
• In an image sensing application, should object recognition be performed on Stage 2 or Stage 3
  – Some results applying SIFT on a Blackfin DSP for Stage 2 and transmitting raw image over radio for Stage 3

Energy and latency when varying arithmetic precision and # of octaves
Exploring Stage Activation Tradeoffs

Energy and latency when varying CPU frequency
(Normalized with respect to transmission)

Energy Aware Platforms - LEAP

- Host Processor Module (HPM)
- Energy Management and Accounting Processor (EMAP2)
- Mini PCI Module (MPM)
- Sensor Interface Module (SIM)
- Low Power Radio Module (LRM)
- CMOS Imager Module (CIM)
**etop – Per Process Energy Accounting**

Based on well-known “top” Unix program

<table>
<thead>
<tr>
<th>Channel</th>
<th>Current (mA)</th>
<th>Power (mW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>116</td>
<td>384</td>
</tr>
<tr>
<td>SDRAM</td>
<td>12.72</td>
<td></td>
</tr>
<tr>
<td>SRAM</td>
<td>0.91</td>
<td></td>
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</tbody>
</table>

**Real-time** display of per-subsystem current/power/energy consumption

**Real-time** display of per-process energy consumption

**Scheduler modifications:**
- measure consumption during system/user time
  - Thanos Stathopoulos

- bash:
  - 0.05 Joules in user mode
  - 0.12 Joules in kernel mode
  - Total energy consumption while process was running: 0.17 J
LabVIEW for Energy Aware Systems

- LabVIEW Domain
  - LabVIEW Virtual Instrument Support Layer
  - LabVIEW Embedded Application
  - LabVIEW Embedded Run-Time Engine for LEAP

- Detection Algorithms
  - Hardware Triggers
  - MATLAB Scripts
  - Embedded Solutions

- Mesh Network Routing Protocols
  - CentRoute
  - OLSR

- Energy-Aware Embedded Linux
  - Comm Links
  - LEAP2 Hardware
  - Energy Accounting

- Web Services
  - Apache Web Server
  - SOAP/XML-Based Applications

- Application Domain
  - C/C++
  - Python
  - Scripts
  - Java

- Sensor Network SA Database
  - Surrounding Motes Database
  - Sensors Availabilities
  - Cluster Topology

- Reconfigurable Embedded Solutions

- Connect as an Instrument

- LabVIEW for Energy Aware Systems

- Timothy Chow
UCLA Telehealth: Driver for greener systems

μLEAP
energy-aware
Telehealth Platform
• Lawrence Au

Smart Cane
Training and guidance in fall prevention

Collaboration Sarrafzadeh (CS), Sayed (EE), Fang (Geriatrics)