Energy-Aware COmputing

The EACO Initiative at Bristol

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The University of Bristol

- 1876, University College
- UoB founded in 1909
  - The first higher education institution in England to admit women on an equal basis to men. 😊
- Top 30 universities globally
  (QS World University Rankings)
- 6 Faculties
- ~14,000 students, 2,000 in FEN
- Computer Science in FEN
- 9 FEN research groups
  - Microelectronics
EACO @ Bristol

The Energy-Aware Computing Initiative, Research Agenda and Workshops

http://www.cs.bris.ac.uk/Research/Micro/eaco.jsp
“To bring together researchers and engineers with interests in energy-aware computing for discussions to identify Intellectual Challenges that can be developed into collaborative research projects.

We strive to go significantly beyond the state of the art.”

[IAS funding application Jan 2010]
Energy-Aware COmputing

- So far 6 dedicated EACO workshops at Bristol:
  - http://www.cs.bris.ac.uk/Research/Micro/eaco.jsp

- Next EACO Workshop (EACO W7):
  - Summer 2014

- Intellectual Challenges
  - Inclusive (up/down system stack)
  - Radically new innovative approaches
  - Strong industrial engagement: Industrial Partners
  - TR: Intellectual Challenges in Energy-Aware COmputing
    http://www.cs.bris.ac.uk/Research/Micro/files/eaco/eaco_w4_intellectual_challenges.pdf
EACO Intellectual Challenges

- IC1 Learning from Biology: More Pre-processing.
- IC2 Learning from Biology: The Dark Silicon Challenge.
- IC3 Learning from Biology: Massively Parallel Extremely Low Power Processing.
- IC4 From “Always On” To “By Default Off”.
- IC5 Power/Energy Characterization of Processor Designs.
- IC6 Power/Energy Characterization of Software.
- IC7 Parallel Design of Complex Software Systems.
- IC8 Low Power Multi-Voltage Design and Verification.
- IC9 Dynamic Power Control of Mobile Computer Systems.
- IC10 More “Power” to Programmers.
- IC11 Raising Energy Consumption Awareness.
- IC12 Energy Autonomous Robots.
- IC13 Communication vs Computation.
  - Re-evaluation of Traditional Metrics for Computational Complexity.
- IC15 Education.
EACO W4 Research Challenges

- Compiler/OS-Level Approaches to Energy Efficiency
- Energy Transparency from SW specification to HW implementation
- Identifying the “Limit”: How to bridge the gap between HW and SW?
- Complexity Metrics for Energy Consumption
- Biologically Inspired Methods
Expose HW properties to enable early system analysis and optimization

**HW to SW**

- Functions
- ISA
- HW Block Profiling
- Toggle Count
- Capacitance

**SW to HW**

Design system tailored to end user needs

**Energy Efficient System**

- Application
- Algorithms
- Program
- Compiler
- OS
- ISA
- Functional Blocks
- RTL (u architecture)
- Synthesis
- Gate
- Layout

Workload
Use Case Analysis
Data Profile
Accuracy
Timing
EACO Research at Bristol

- EACO Platform
  - Online power monitoring
  - RTOS API

- EACOF (github.com/eacof)
  - Instrumentation of SW

- Machine Guided Energy Efficient Compilation (MAGEEC)

- Whole Systems Energy Transparency (ENTRA)
# Energy-efficient computing devroom

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Speakers</th>
<th>Start</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00</td>
<td>Energy scavenging, battery life and should we build more power stations. Why energy-efficiency of hardware and software matters.</td>
<td>Jeremy Bennett</td>
<td>9:00</td>
<td>9:30</td>
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<tr>
<td>9:30</td>
<td>Measuring energy consumption in embedded systems</td>
<td>Simon Holis</td>
<td>9:30</td>
<td>10:15</td>
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<tr>
<td>10:15</td>
<td>An approach for energy consumption analysis of programs using LLVM</td>
<td>Kerstin Eder, Kynakos Georgiou, Neville Grech</td>
<td>10:15</td>
<td>10:45</td>
</tr>
<tr>
<td>10:45</td>
<td>sPEEDO: Energy Efficiency through Debug support</td>
<td>David Greaves</td>
<td>10:45</td>
<td>11:45</td>
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<tr>
<td>11:45</td>
<td>Open Energy Measurement Hardware</td>
<td>James Pallister</td>
<td>11:45</td>
<td>12:15</td>
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<tr>
<td>12:15</td>
<td>Open Low Power Devices</td>
<td>Emilio Monti</td>
<td>12:15</td>
<td>12:30</td>
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</tbody>
</table>
Thank you for your attention
MAGEEC

Machine-Guided Energy-Efficient Compilation

in collaboration with Embecosm Ltd
with funding from the UK TSB
Impact of Compiler Flags

Figure: Graph showing the impact of various compiler flags on energy and time, with significant changes highlighted.
MAGEEC Framework

Diagram showing the components of the MAGEEC Framework, including:
- Training set
- Energy measurement
- Machine learner
- Feature extractor
- Program
- Optimized Program
- Optimizer
- Classifier
- Decision tree
- Compiler

The diagram illustrates the flow of information and processes from training set measurements to energy consumption, feature extraction, machine learning, and classification, leading to optimized programs and decision-making.