MAchine Guided Energy Efficient Compilation

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The Impact of Different Compiler Options on Energy Consumption

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Motivation

- Compiler optimizations are claimed to have a large impact
  - performance
  - code size
  - energy usage
- No *extensive* study prior to this considering
  - different benchmarks
  - individual optimizations
  - different platforms
- This work looks at the effect of
  - many different optimizations
  - 10 benchmarks
  - 5 platforms.
- Over 200 Optimization passes covered by around 150 flags
Key Components

- Importance of benchmarks
  - new set defined for embedded systems
- Choice of platforms
  - Epiphany, XMOS and 3 flavors of ARM
- How to explore $2^{150}$ combinations of options
  - fractional factorial design
- Energy measuring hardware
  - *not* simulation
- Result: Large dataset of extensive results
Results

- **Time ≈ Energy**
  - true for simple pipelines
  - mostly true for complex pipelines
  - good first approximation

- **Optimization is very unpredictable**
  - difficult to model the interactions between optimizations

- **There is only modest commonality**
  - some common options for a single architecture
  - some common options within the ARM family
  - sometimes common options across a benchmark
Results

- **Time ∼ Energy**
  - true for simple pipelines
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  - good first approximation
- **Optimization is very unpredictable**
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- **There is only modest commonality**
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- **Summary: You can't predict which optimizations are best**
What is MAGEEC?

Today we optimize for speed or space
What is MAGEEC?

Today we optimize for speed or space

What if we could optimize for energy usage?
Research into modeling energy usage
How We Got Here

Research into modeling energy usage  Energy measurement
How We Got Here

Research into modeling energy usage

Energy measurement

Research into feedback directed optimization
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Technology Strategy Board
Driving Innovation
What's New?

Objective is energy optimization
What's New?

Objective is energy optimization

Energy measured *not* modeled
Objective is energy optimization

Energy measured *not* modeled

Generic framework: GCC and LLVM initially
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Energy measured *not* modeled

Generic framework: GCC and LLVM initially

Working system, not research prototype
Implementation
Our Plan

- Implement MILEPOST concepts in a generic way.
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- Train and evaluate based on real hardware energy measurements and existing passes.
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- Implement MILEPOST concepts in a generic way.
- Train and evaluate based on real hardware energy measurements and existing passes.
- Write and evaluate optimization passes specifically for energy efficiency (Jörn Rennecke).
Overall Design

Compiler

Coordinator

Machine Learner

Plugin I/F

ML I/F

MAGEEC
Overall Design

Compiler
- plugin_init()
- gen_features()
- run_pass()
- stats_gen()
- end()

Coordinator
- init()
- decision()
- next_pass()
- mod_stats()
- end()

Machine Learner
- init()
- decision()
- decision()
- end()
Community Involvement

MAGEEC
Machine Guided Energy Efficient Compilation

Category: Planning
This category holds all documents available under a Creative Commons license.

Category: Design
This page contains all the documents in the Design category.

Interface Flow
This page describes the interfaces and basic flow of how the three components of MAGEEC will communicate. Between the components are the direction of communication along with what data is communicated.
Further Reading

- **Energy measuring and modeling**

- **MILEPOST GCC - Feedback directed optimization**
  - [ctuning.org/milepost-gcc](http://ctuning.org/milepost-gcc)

- **Measurement of compiler energy usage**

- **MAGEEC**
  - [mageec.org](http://mageec.org)
Thank you

mageec.org
www.embecosm.com
cs.bris.ac.uk