**MAchine Guided Energy Efficient Compilation**

Experience of TSB Feasibility Funding

Dr Jeremy Bennett, CEO Embecosm
Do Compilers Affect Energy?

- Initial research in 2012 by Embecosm and Bristol University
- The answer is “yes”
- Now published open access in a peer-reviewed journal

Identifying Compiler Options to Minimize Energy Consumption for Embedded Platforms
James Pallister; Simon J. Hollis; Jeremy Bennett
Recap: What is MAGEEC?

Today we optimize for speed or space

What if we could optimize for energy usage?
Recap: How We Got Here

Research into feedback directed optimization

Research into modeling energy usage

Energy measurement
Recap: What's New?

Objective is energy optimization

Energy measured *not* modeled

Generic framework: GCC and LLVM initially

Working system, not research prototype
A Free and Open Source Energy Measurement System

mageec.org/wiki/Power_Sensing_Board
The **Bristol/Embecosm Embedded Benchmark Suite**
- a free and open source benchmark suite for embedded use

**Underlying principles**
- GPL licensed
- no I/O
- avoid library calls

**BEEBS 2.0 scheduled for release 31 August 2014**
- target 100
- some data variants of the same test
// Machine guided
class EnergyEfficientCompilation {
public:
    Machine
~Machine()
void Train (EC::FeatureSet noisy)
void Predict (EC::FeatureSet<>
bool choose (std::string);
private:
    MagicWand Mage;
## Results for AVR ATmega328PU

<table>
<thead>
<tr>
<th></th>
<th>Standard GCC -O0</th>
<th>MAGEEC GCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>29.8 mJ</td>
<td>27.6 mJ</td>
</tr>
<tr>
<td>Time</td>
<td>329.1 ms</td>
<td>309.8 ms</td>
</tr>
<tr>
<td>Power</td>
<td>90.6 mW</td>
<td>89.1 mW</td>
</tr>
<tr>
<td>Average current</td>
<td>17.9 mA</td>
<td>17.6 mA</td>
</tr>
<tr>
<td>Average voltage</td>
<td>5.1 V</td>
<td>5.1 V</td>
</tr>
</tbody>
</table>

- Based on minimal training:
  - just 10 single function programs
  - 700 training runs
Where Can I Get It?

- **Project Website:** [http://mageec.org](http://mageec.org)

- **MAGEEC Source:** [http://github.com/mageec/mageec](http://github.com/mageec/mageec)

- **BEEBS:** [http://github.com/mageec/beebs](http://github.com/mageec/beebs)

- **Mailing List:** [mageec@mageec.org](mailto:mageec@mageec.org)

- **IRC:** #mageec on Freenode
TSB Funding
Experience of a TSB Feasibility Study

- £150 project, Embecosm (70%) and Bristol University (30%)
- Application took 6 days work from Embecosm to prepare
  - similar effort from Bristol University
- Process was reasonably quick
  - apply November 2012
  - conditional offer Feb 2013
  - grant confirmation April 2013
  - project start June 2013
- Clear and supportive quarterly review process
  - prompt payment of grant following review
£150k project, split 70% Embecosm, 30% Bristol University
- Bristol 100% funded, Embecosm 75%
- With 27.5% R&D tax credit, direct cost to Embecosm is £19k

Remember the hidden costs
- opportunity cost of application (£8.5k)
- management and audit (£8.5k)
- lost R&D tax credit (£21.7k)
- but at 75% funding, the initiative was still very worthwhile

In summary:
- make sure you consider all the costs
- for a project you want to do, but unfunded is too risky
Some Things That We Learned

- Reviewers comments can be contradictory
  - they are technical, but generalists
  - but they may hold opinions on your field
  - a “viva” part of the review could help this

- Working completely open source was very effective
  - gained a great deal of publicity very early
  - TSB templates aren't ideal for this, but can be adapted

- Using undergraduates is good value
  - 1 x summer postdoc = 3 x undergraduate summer interns
  - undergraduates incredibly motivated
  - excellent PhD preparation
// Machine guided
class EnergyEfficientCompilation {
public:
  Machine
~Machine()
readTrain(MageEC::FeatureSet, EnergyResult);
  void Predict(MageEC::FeatureSet<>);
  bool chooseSensor(std::string);
private:
  MagicWand MageWandEnergy;
};

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