Post-compiler Software Optimization for Reducing Energy

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March 4, 2014
What is GOA?

Genetic Optimization Algorithm
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Genetic Optimization Algorithm

Post Compiler

source $\rightarrow$ GCC $\rightarrow$.s $\rightarrow$ GOA $\rightarrow$.s $\rightarrow$.exe
What is GOA?

**Genetic Optimization Algorithm**

Post Compiler

source → **GCC** → .s → GOA → .s → .exe

Genetic

width=1

Copy

Delete

Swap

Two Point Crossover
What is GOA?

Genetic Optimization Algorithm

Post Compiler

source → .s → GOA → .s → .exe

Genetic width=1

Copy

Delete

Swap

Two Point Crossover

ASPLOS 2014
Modified Semantics – Blackscholes
Hardware Specific – Swaptions
Modified Resources – Vips
Genetic Optimization Algorithm (GOA)

- **Source Code**
  - Compile
  - Assembler
  - Link
  - Executable

- **Fitness Function**
  - Minimize
  - Best
  - Cycles of seed with fitness
  - Population

- **Test Suite**
  - Insert
  - Profile
  - Transformation

- **Optimization**
  - Select
  - Link

- **Inputs**
  - Copy
  - Run
Mutation Operations

Copy

Delete

Swap

Two Point Crossover

ASPLOS 2014
Energy Model

\[ \text{power} = C_{\text{const}} + C_{\text{ins}} \frac{\text{ins}}{\text{cycle}} + C_{\text{flops}} \frac{\text{flops}}{\text{cycle}} + C_{\text{tca}} \frac{\text{tca}}{\text{cycle}} + C_{\text{mem}} \frac{\text{mem}}{\text{cycle}} \]

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Description</th>
<th>Intel (4-core)</th>
<th>AMD (48-core)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_{\text{const}} )</td>
<td>constant power draw</td>
<td>31.530</td>
<td>394.74</td>
</tr>
<tr>
<td>( C_{\text{ins}} )</td>
<td>instructions</td>
<td>20.490</td>
<td>-83.68</td>
</tr>
<tr>
<td>( C_{\text{flops}} )</td>
<td>floating point ops.</td>
<td>9.838</td>
<td>60.23</td>
</tr>
<tr>
<td>( C_{\text{tca}} )</td>
<td>cache accesses</td>
<td>-4.102</td>
<td>-16.38</td>
</tr>
<tr>
<td>( C_{\text{mem}} )</td>
<td>cache misses</td>
<td>2962.678</td>
<td>-4209.09</td>
</tr>
</tbody>
</table>

Table: Power model coefficients.
## Benchmark Applications

<table>
<thead>
<tr>
<th>Program</th>
<th>C/C++ Lines of Code</th>
<th>ASM Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>blackscholes</td>
<td>510</td>
<td>7,932</td>
<td>Finance modeling</td>
</tr>
<tr>
<td>bodytrack</td>
<td>14,513</td>
<td>955,888</td>
<td>Human video tracking</td>
</tr>
<tr>
<td>ferret</td>
<td>15,188</td>
<td>288,981</td>
<td>Image search engine</td>
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<tr>
<td>fluidanimate</td>
<td>11,424</td>
<td>44,681</td>
<td>Fluid dynamics animation</td>
</tr>
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<td>freqmine</td>
<td>2,710</td>
<td>104,722</td>
<td>Frequent itemset mining</td>
</tr>
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<td>swaptions</td>
<td>1,649</td>
<td>61,134</td>
<td>Portfolio pricing</td>
</tr>
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<td>vips</td>
<td>142,019</td>
<td>132,012</td>
<td>Image transformation</td>
</tr>
<tr>
<td>x264</td>
<td>37,454</td>
<td>111,718</td>
<td>MPEG-4 video encoder</td>
</tr>
<tr>
<td>total</td>
<td>225,467</td>
<td>1,707,068</td>
<td></td>
</tr>
</tbody>
</table>

Table: Selected PARSEC benchmark applications.
Multivariate Breeders Equation

Natural Selection into phenotypic traits [?, Chpt. 4].

$$\Delta \hat{Z} = G\beta$$