Mnemosyne: Program Analysis Tools for HPC Code Optimization

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Application Behavior Problem

• HPC codes are written by domain experts - not computer systems engineers

• Naïve implementations lead to bottlenecks which are typically platform specific

• HPC hardware architectures will continue to change rapidly
  – a new platform often means repeating the optimization process
Solution: Mnemosyne

Program Source Code (Fortran/C/C++)

Compile Program on Test Platform (Linux 8-core x86)

Application Developer

Program Binaries

Run Program in Mnemosyne Supervised Executor

Platform Models

Behavioral Data

Mnemosyne Data Fusion & Analysis

Data Visualization & Code Optimization

Summary Data

Verification & Further Optimization
Experimental Results

<table>
<thead>
<tr>
<th>Application</th>
<th>Language</th>
<th>Description</th>
<th>SLOC</th>
<th>Speedup</th>
<th>Behaviors</th>
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<tr>
<td>CIT Airshed</td>
<td>Fortran</td>
<td>Models formation and dispersal of atmospheric pollutants</td>
<td>0.4K</td>
<td>2x</td>
<td>Memory striding, Function Invariants</td>
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<tr>
<td>LIBQuantum</td>
<td>C</td>
<td>Quantum mechanics simulation</td>
<td>37K</td>
<td>1.75x</td>
<td>Memory striding</td>
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<tr>
<td>GNU Go</td>
<td>C</td>
<td>Artificial intelligence playing the game ‘Go’</td>
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<td>Memory striding, Branch invariants</td>
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<tr>
<td>OpenLB Poiseuille2D</td>
<td>C++</td>
<td>Computational Fluid Dynamics Simulation</td>
<td>55K</td>
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<tr>
<td>ICEPIC</td>
<td>C</td>
<td>High power microwave physics modeling</td>
<td>78K</td>
<td>1x</td>
<td>Memory striding, Branch invariants, Misaligned Accesses</td>
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</table>

- All applications are compiled with dwarf-2 debugging symbols and level 0 optimization.