HPCG benchmark for characterizing the performance of SoC devices

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Introduction

• HPCG: An emerging and effective tool for performance benchmarking.

• SoCs: Benefit from the use of parallel programming model.

• Two Competing APIs for harnessing computational resources: CUDA and OpenCl
Motivation

• HPL No longer strongly correlated to real application performance (Type1/2 usage patterns).
• Encourages poor choices in architectural features
• Benchmarking for days wastes a valuable resource
• HPCG
  • Essential application usage patterns
  • Limited support for device architectures and platforms
Background (HPCG)

- Solves a system of linear equations, $Ax = b$.
- Constructs a 3 dimensional 27 point stencil matrix.
- Four Steps in Execution
  - MultiGrid Preconditioner (MG)
  - Sparse matrix vector multiplication (SPMV)
  - Scaled vector addition (WAXPBY)
  - Dot Product (DP)
Design and Implementation

• Theoretical Model Conclusion
  • Limited CPU performance
  • Execution for large problem size
  • Unified memory access

![Diagram showing GPU and CPU connections with high, medium, and main memory bandwidths.](image)
Design and Implementation

• Implementation of algorithms
  • Preloading Matrices
  • Non blocking memory writes
  • Vector operations
  • Pinned memory - prevents swapping
  • Unified memory - managed shared memory
  • Processing multiple items per thread
  • Rearranging Matrices for unit stride access
Results

- Testing done on Jetson and FireFly SoC hardware.
  - Comparison of Wall time
Results

- Floating point operations per second
## Results

- **Energy Consumption**

<table>
<thead>
<tr>
<th>System</th>
<th>Type</th>
<th>SPMV (J)</th>
<th>Dot Product (J)</th>
<th>WAXPBY (J)</th>
<th>MG (J)</th>
<th>Total (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jetson</td>
<td>Serial</td>
<td>4.935</td>
<td>0.130</td>
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<td>0.073</td>
<td>0.066</td>
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<td>14.367</td>
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<tr>
<td>FireFly</td>
<td>Serial</td>
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<td>0.127</td>
<td>0.154</td>
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<td>0.037</td>
<td>0.035</td>
<td>28.234</td>
<td>29.610</td>
</tr>
</tbody>
</table>

Energy consumed in Joules
Conclusion

• Benchmarking of SoCs
  – Low memory transfer bandwidth and speed
  – Low double precision performance
• Implementation of GS preconditioner
• High level of power efficiency makes the benchmark desirable.
Questions