Verification of Resilient Communication Models for the Simulation of a Highly Adaptive Energy-Efficient Computing Platform

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Motivation and Goal

- HAEC Box: high performance-low energy computing box [1].
- Optical (on-board) chip-to-chip communication.
- Wireless (intra-board) chip-to-chip communication.
- Software stack adaptivity.
- Hardware adapts to the needs of the computational problem.
- HAEC-SIM: integrated simulation environment for studying the performance and energy costs of the HAEC Box [2].
- Simulator design based on individual abstraction models of:
  - Hardware (e.g., CPUs, links).
  - Architecture (e.g., computing nodes, network).
- Software (e.g., runtime system, code generation).
- Goal: The goal of this work is the verification of the resilient communication models [3] implemented in HAEC-SIM [2].

HAEC Box Specifications

- Four boards, each with 4 computing nodes.
- Each computing node comprises 3D stacked processor chips which contain a large number of "thin" cores.

Applications

- The benchmarks LUD.4096 and BT.4096 of the NAGA Parallel Benchmark Suite 3.3 are chosen as example applications.
- Both benchmarks are communication intensive: LUD.4096 spends approximately 68 % in MPI functions, while BT.4096 spends approximately 48 % (Table 2).

<table>
<thead>
<tr>
<th>Computing Node</th>
<th>Optical Links</th>
<th>Wireless Links</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topology</td>
<td>2D torus</td>
<td>fully connected crossbar</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>2.5 Gbps</td>
<td>100 Gbps</td>
</tr>
<tr>
<td>Latency</td>
<td>10 ns</td>
<td>100 ns</td>
</tr>
<tr>
<td>Bit error rate</td>
<td>10⁻⁸</td>
<td>10⁻⁹</td>
</tr>
</tbody>
</table>

Communication Models

- DOR: (dimensionless dynamic network coding).
- PNC: (practical network coding).
- NCD: (resilient dynamical network coding).

Message Transfer Times

(a) Message transfer times per message size, and (b) Message data rates per message size for the simulated execution of LU.D.4096 on the target HPC platform topology, HAEC-SIM, and NCD, right, are communication models.

Number of Hops per Message

- Distribution of the number of hops per message.
- For the target HPC platform topology.
- Depends on processes-to-nodes mapping and communication patterns.
- Influences communication-to-computation ratio.

References


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