TOWARDS THE EXPLORATION OF DYNAMIC MULTIPATH ROUTING IN 3D TORUS NETWORKS THROUGH THE CODES/ROSS SIMULATION FRAMEWORK

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Abstract
Torus Networks are an important and widely used architecture in modern supercomputers. These supercomputers frequently employ static routing protocols like Dimension Order Routing (DOR). While simple and easy to implement, we theorize that DOR methods incur excessive network latencies due to poor load balancing. In this work, we first characterize such behavior under the current standard protocol, then introduce a simple Randomized Dynamic Routing (RDR) protocol. We demonstrate that even such simplistic dynamic routing protocols offer lower, more scalable latencies over a 3D torus network. As supercomputing moves towards exascale, such scalability will be necessary to cope with unprecedented workloads and network sizes. These results were generated using the CODES highly parallel simulator.

Routing Procedure
- If at destination: DONE
- Else, for each dimension, determine whether it would be advantageous to travel in the positive direction, negative direction, or not move, using the half length of the network. If travel over that dimension is viable, mark that dimension VIABLE.
- Randomly select a dimension marked VIABLE, travel one node in the appropriate direction, then call RDR again.

Latencies under Different Network Loads

<table>
<thead>
<tr>
<th>Dimension Order Routing</th>
<th>Randomized Dynamic Routing</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 Active Nodes</td>
<td>1000 Active Nodes</td>
</tr>
</tbody>
</table>

Compared Latencies

<table>
<thead>
<tr>
<th>Percent Decrease</th>
<th>Latency Median</th>
<th>95th Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 Nodes</td>
<td>30.3%</td>
<td>33.6%</td>
</tr>
<tr>
<td>250 Nodes</td>
<td>32.5%</td>
<td>41.7%</td>
</tr>
<tr>
<td>500 Nodes</td>
<td>36.2%</td>
<td>43.0%</td>
</tr>
<tr>
<td>1000 Nodes</td>
<td>36.9%</td>
<td>41.9%</td>
</tr>
</tbody>
</table>

Challenges
- Provide performance increase without excessive overhead
- Route protocol must scale to large networks and heavy traffic

Proposed Solution
- Use randomization to spread traffic more evenly across the network
- Sufficiently simple to avoid excess overhead and to scale well

Conclusions
- Dimension Order Routing incurs significant latency penalties as network traffic increases
- Our Randomized Dynamic Routing protocol offers significant speedup over Dimension Order Routing and scales better to high traffic
- Dynamic multipath routing has potential to improve supercomputer performance

References