Debugging BOOM-v2 with FPGA Simulation

Donggyu Kim

Berkeley Architecture Research

ASPIRE End of Project Party

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Strober Power/Energy Modeling [1]

Full Program Execution In FPGA

RTL State Snapshots

I/O Traces

RTL/Gate-level Simulation

Signal Activities

Gate-level Designs

Power Analysis Tool

Average Power

Whenever we see this...

Segmentation fault
Custom Compiler Passes

- **Assertion & Print Synthesis**
  - Assertions and prints in FPGA

- **FAME1 Transform**
  - Accurate performance modeling in FPGA
  - Deterministic simulation with the same initial state

- **Scan Chain Insertion**
  - Initialize the target state
  - RTL state snapshot for error replays
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FPGA-Accelerated RTL Verification

- **Master** catches errors from assertion
- **Slave** takes an RTL state snapshot for replays
- **Software simulation** replays the RTL snapshot for full visibility

Master Simulation Instance
- FPGA-accelerated RTL Simulation (Trillions of Instructions)

Slave Simulation Instance
- FPGA-accelerated RTL Simulation (Trillions of Instructions)

RTL State Snapshot

SW RTL Simulation
- (Hundreds of Instructions)
Where Is the Bug?

- Mispredict & Kill
- Roll back
- Wrong Data
- Wrong Data
This Bug was Fixed!

[util] Fix bug in FPtoIN queue.
* Bad copy/paste of flow-through queue causes valid to be set
even for entries killed by a branch misspeculation.

h/t @donggyukim.

@ master v2.0.1

ccelio committed on Sep 11

Showing 1 changed file with 7 additions and 5 deletions.

@@ -44,7 +44,7 @@ object GetNewUopAndBrMask

    {
        val newuop = Wire(init = uop)
-       newuop.br_mask :=
+       newuop.br_mask :=

        Mux(brinfo.valid,
            (uop.br_mask & ~brinfo.mask),
            uop.br_mask)

@@ -278,6 +278,7 @@ object AgePriorityEncoder

    }

    +// Assumption: enq.valid only high if not killed by branch (so don't check IsKilled on io.enq).
### BOOM-v2 Assertion Results

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Assertion</th>
<th>Cycle(B)</th>
<th>Simulation Time (Min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>483.xalancbmk.test</td>
<td>Invalid write back in ROB</td>
<td>1.9</td>
<td>3.4</td>
</tr>
<tr>
<td>464.h264ref.test</td>
<td>Pipeline hung</td>
<td>3.2</td>
<td>3.8</td>
</tr>
<tr>
<td>471.omnetpp.test</td>
<td>Pipeline hung</td>
<td>3.3</td>
<td>3.9</td>
</tr>
<tr>
<td>445.gobmk.test</td>
<td>Invalid write back in ROB</td>
<td>14.9</td>
<td>9.0</td>
</tr>
<tr>
<td>471.omnetpp.ref</td>
<td>Pipeline hung</td>
<td>62.6</td>
<td>22.2</td>
</tr>
<tr>
<td>401.bzip2.ref</td>
<td>Wrong JAL target</td>
<td>473.7</td>
<td>164.6</td>
</tr>
</tbody>
</table>

- Cost: 2 x 50 cents / hour
- Total cost: $2 (compilation) + 2 x $1.56 (simulation) = $5.12