Appendix: Detailed Results

This document includes the detailed results for the paper “High-Bandwidth Address Translation for Multiple-Issue Processors”, by Todd M. Austin and Gurindar S. Sohi in ISCA-23, May 1996.

Table 1: Program Execution Performance. Instruction, load, and store counts include only non-speculative operations. The columns labeled Issue and C’mit indicate the average number of operations issued and committed per cycle, respectively, on the baseline 8-way out-of-order issue processor simulator.

<table>
<thead>
<tr>
<th>Program</th>
<th>Inputs/Options</th>
<th>Insts (Mil.)</th>
<th>Loads (Mil.)</th>
<th>Stores (Mil.)</th>
<th>Inst/Cycle Issue</th>
<th>(Ld+St)/Cycle Issue</th>
<th>Br Pred Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compress</td>
<td>-</td>
<td>0.987</td>
<td>0.734</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Doduc</td>
<td>-</td>
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<td>1.000</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
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<td>-</td>
<td>0.996</td>
<td>1.000</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>GCC</td>
<td>-</td>
<td>0.998</td>
<td>1.000</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Ghostscript</td>
<td></td>
<td>0.997</td>
<td>1.000</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
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<td>-</td>
<td>0.996</td>
<td>1.000</td>
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<td>0.0</td>
<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
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<td>-</td>
<td>0.996</td>
<td>1.000</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
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<td>-</td>
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<td>1.000</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Table 2: Relative Performance on Baseline Simulator. Results shown are run-time weighted average IPCs normalized to the performance of design T4. All experiments were run on an 8-way out-of-order issue processor simulator with 32 registers and 4k pages.

<table>
<thead>
<tr>
<th>Program</th>
<th>Multi-ported T4-IPC</th>
<th>Multi-level/Pretranslated T4-IPC</th>
<th>Interleaved T4-IPC</th>
<th>Piggybacked T4-IPC</th>
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<tbody>
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<td>0.0</td>
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<td>2.900</td>
<td>1.000</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>GCC</td>
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<td>1.000</td>
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<td>MPEGplay</td>
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</tr>
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<td>Perl</td>
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<td>0.0</td>
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<tr>
<td>Tomcatv</td>
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<td>0.0</td>
</tr>
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<td>1.000</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>RTW Avg</td>
<td>2.094</td>
<td>1.000</td>
<td>0.0</td>
<td>0.0</td>
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</table>

Table 3: TLB miss rates. All values shown indicate percent of all references that miss. The row labeled RTW Avg is the run-time weighted average miss rate over all the benchmarks (weighted by the run-time of configuration T4). The 4, 8, and 16 entry TLBs are managed with LRU replacement, and the 32, 64, and 128 entry TLBs are managed with random replacement.
<table>
<thead>
<tr>
<th>Program</th>
<th>Insts (Mil.)</th>
<th>Loads (Mil.)</th>
<th>Stores (Mil.)</th>
<th>Inst/Cycle</th>
<th>(Ld+St)/Cycle</th>
<th>Br Pred</th>
<th>Rate (%)</th>
<th>Inst/Cycle</th>
<th>(Ld+St)/Cycle</th>
<th>Br Pred</th>
<th>Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compress</td>
<td>62.0</td>
<td>15.8</td>
<td>6.1</td>
<td>1.31</td>
<td>1.23</td>
<td>0.45</td>
<td>0.43</td>
<td>89.4</td>
<td>3.65</td>
<td>1.96</td>
<td>1.30</td>
</tr>
<tr>
<td>Doduc</td>
<td>1.375</td>
<td>330.4</td>
<td>130.2</td>
<td>1.01</td>
<td>0.97</td>
<td>0.33</td>
<td>0.32</td>
<td>86.4</td>
<td>2.16</td>
<td>1.76</td>
<td>0.71</td>
</tr>
<tr>
<td>Espresso</td>
<td>517.5</td>
<td>116.5</td>
<td>32.7</td>
<td>1.50</td>
<td>1.41</td>
<td>0.43</td>
<td>0.41</td>
<td>88.8</td>
<td>4.48</td>
<td>2.90</td>
<td>1.32</td>
</tr>
<tr>
<td>GCC</td>
<td>110.6</td>
<td>20.4</td>
<td>16.5</td>
<td>1.35</td>
<td>1.27</td>
<td>0.56</td>
<td>0.49</td>
<td>78.8</td>
<td>3.56</td>
<td>1.87</td>
<td>1.32</td>
</tr>
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<td>625.2</td>
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<td>53.3</td>
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<td>1.30</td>
<td>0.35</td>
<td>0.33</td>
<td>94.3</td>
<td>2.76</td>
<td>2.18</td>
<td>0.73</td>
</tr>
<tr>
<td>MPEG_play</td>
<td>529.6</td>
<td>114.9</td>
<td>47.9</td>
<td>1.36</td>
<td>1.29</td>
<td>0.42</td>
<td>0.40</td>
<td>84.6</td>
<td>4.11</td>
<td>2.83</td>
<td>1.76</td>
</tr>
<tr>
<td>Perl</td>
<td>231.5</td>
<td>57.7</td>
<td>37.2</td>
<td>1.32</td>
<td>1.10</td>
<td>0.52</td>
<td>0.44</td>
<td>79.4</td>
<td>2.85</td>
<td>1.43</td>
<td>1.05</td>
</tr>
<tr>
<td>TFT</td>
<td>959.8</td>
<td>136.6</td>
<td>89.4</td>
<td>1.17</td>
<td>1.04</td>
<td>0.27</td>
<td>0.24</td>
<td>84.5</td>
<td>2.70</td>
<td>1.79</td>
<td>0.62</td>
</tr>
<tr>
<td>Tomcatv</td>
<td>359.7</td>
<td>90.9</td>
<td>18.3</td>
<td>1.12</td>
<td>1.09</td>
<td>0.34</td>
<td>0.33</td>
<td>86.0</td>
<td>3.67</td>
<td>2.73</td>
<td>1.00</td>
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<tr>
<td>Xlisp</td>
<td>962.7</td>
<td>289.2</td>
<td>171.6</td>
<td>1.55</td>
<td>1.42</td>
<td>0.73</td>
<td>0.68</td>
<td>87.2</td>
<td>4.17</td>
<td>2.52</td>
<td>1.86</td>
</tr>
</tbody>
</table>

Table 4: Program Execution Performance. Instruction, load, and store counts include only non-speculative operations. The columns labeled Issue and Cmit indicate the average number of operations issued and committed per cycle, respectively.
### Table 7: Program Execution Performance.

<table>
<thead>
<tr>
<th>Program</th>
<th>Insts (Mil.)</th>
<th>Loads (Mil.)</th>
<th>Stores (Mil.)</th>
<th>Inst/Cycle</th>
<th>C'mit</th>
<th>Ld+St/Cycle</th>
<th>C'mit</th>
<th>Br Pred Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compress</td>
<td>72.9</td>
<td>18.6</td>
<td>6.1</td>
<td>3.64</td>
<td>2.12</td>
<td>1.22</td>
<td>0.72</td>
<td>90.2</td>
</tr>
<tr>
<td>Doduc</td>
<td>1,616.4</td>
<td>457.1</td>
<td>227.0</td>
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<td>1.93</td>
<td>0.97</td>
<td>0.82</td>
<td>86.4</td>
</tr>
<tr>
<td>Espresso</td>
<td>621.1</td>
<td>182.2</td>
<td>65.1</td>
<td>4.46</td>
<td>3.38</td>
<td>1.78</td>
<td>1.33</td>
<td>92.5</td>
</tr>
<tr>
<td>GCC</td>
<td>119.5</td>
<td>33.1</td>
<td>19.8</td>
<td>3.64</td>
<td>1.96</td>
<td>1.57</td>
<td>0.87</td>
<td>80.8</td>
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<tr>
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<td>651.5</td>
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<td>1.96</td>
<td>0.96</td>
<td>0.56</td>
<td>89.5</td>
</tr>
<tr>
<td>MPEG_play</td>
<td>704.3</td>
<td>225.1</td>
<td>101.6</td>
<td>4.31</td>
<td>2.80</td>
<td>1.83</td>
<td>1.30</td>
<td>81.1</td>
</tr>
<tr>
<td>Perl</td>
<td>241.0</td>
<td>61.6</td>
<td>42.4</td>
<td>2.86</td>
<td>1.46</td>
<td>1.23</td>
<td>0.63</td>
<td>81.4</td>
</tr>
<tr>
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<td>181.6</td>
<td>3.04</td>
<td>2.24</td>
<td>1.15</td>
<td>0.97</td>
<td>79.4</td>
</tr>
<tr>
<td>Tomcatv</td>
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<td>355.3</td>
<td>131.7</td>
<td>5.47</td>
<td>5.44</td>
<td>1.35</td>
<td>1.35</td>
<td>89.3</td>
</tr>
<tr>
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<td>4.22</td>
<td>2.59</td>
<td>1.87</td>
<td>1.20</td>
<td>89.3</td>
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</table>

### Table 8: Relative Performance with Fewer Registers (8 int/8 fp).

<table>
<thead>
<tr>
<th>Program</th>
<th>T4-IPC</th>
<th>T4</th>
<th>T2</th>
<th>T1</th>
<th>M16</th>
<th>M8</th>
<th>M4</th>
<th>P8</th>
<th>I8</th>
<th>I4</th>
<th>X4</th>
<th>PB2</th>
<th>PB1</th>
<th>I4/PB</th>
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<tbody>
<tr>
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<td>1.000</td>
<td>0.947</td>
<td>0.698</td>
<td>0.932</td>
<td>0.913</td>
<td>0.887</td>
<td>0.967</td>
<td>0.900</td>
<td>0.883</td>
<td>0.888</td>
<td>0.997</td>
<td>0.929</td>
<td>0.994</td>
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<tr>
<td>Doduc</td>
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<td>0.999</td>
<td>0.994</td>
<td>0.986</td>
<td>0.980</td>
<td>0.893</td>
<td>0.878</td>
<td>0.883</td>
<td>0.997</td>
<td>0.949</td>
<td>0.993</td>
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<tr>
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<td>0.814</td>
<td>0.728</td>
<td>0.731</td>
<td>0.964</td>
<td>0.999</td>
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<tr>
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<td>0.967</td>
<td>0.959</td>
<td>0.904</td>
<td>0.893</td>
<td>0.910</td>
<td>0.996</td>
<td>0.938</td>
<td>0.983</td>
</tr>
<tr>
<td>MPEG_play</td>
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<td>0.984</td>
<td>0.971</td>
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<td>0.991</td>
<td>0.897</td>
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<td>TFFT</td>
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<td>0.652</td>
<td>1.000</td>
<td>0.998</td>
<td>0.977</td>
<td>0.996</td>
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<td>0.713</td>
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<td>1.000</td>
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<tr>
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<td>0.998</td>
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<td>0.992</td>
<td>0.892</td>
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