Designing a Custom Architecture for DCT Using NISC Design Flow

Bita Gorjiara, Mehrdad Reshadi, Daniel Gajski
Center for Embedded Systems (CECS)
University of California, Irvine
{bgorjiar, reshadi, gajski}@cecs.uci.edu
Web: www.cecs.uci.edu/~nisc
NISC Technology

**CISC**
- PC
- Program Memory
- mPC
- mPM
- Data Memory
- Data path
- Complex instructions
  - One instruction = several CW
  - PM standard

**RISC**
- PC
- Program Memory
- IR
- Decoder
- Data Memory
- Data path
- Simple instructions
  - One instruction = One CW
  - PM longer

**NISC**
- PC
- Program Memory
- Data Memory
- Data path
- No instructions
  - Several operations = One CW
  - PM shorter and wider
DCT example

- Software transformations and hardware customizations
  - Loop unrolling
  - Operation chaining
  - ALU and comparator optimization
  - Controller pipelining
  - Bit-width reduction
Summary of Results

- Xilinx Virtex II 2000 FPGA
- NMIPS vs. CDCT7:
  - 10 times performance improvement
  - 1.3 times power reduction
  - 12.8 energy reduction
  - 2.9 area reduction
- Designs are available online

<table>
<thead>
<tr>
<th></th>
<th>No. of cycles</th>
<th>Clock Freq (MHz)</th>
<th>DCT exec. Time (us)</th>
<th>Dynamic Power (mW)</th>
<th>Normalized area</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMIPS</td>
<td>10772</td>
<td>78.3</td>
<td>137.57</td>
<td>177.33</td>
<td>1.00</td>
</tr>
<tr>
<td>CDCT1</td>
<td>3080</td>
<td>85.7</td>
<td>35.94</td>
<td>120.52</td>
<td>0.81</td>
</tr>
<tr>
<td>CDCT2</td>
<td>2952</td>
<td>90.0</td>
<td>32.80</td>
<td>111.27</td>
<td>0.71</td>
</tr>
<tr>
<td>CDCT3</td>
<td>2952</td>
<td>114.4</td>
<td>25.80</td>
<td>82.82</td>
<td>0.40</td>
</tr>
<tr>
<td>CDCT4</td>
<td>3080</td>
<td>147.0</td>
<td>20.95</td>
<td>125.00</td>
<td>0.46</td>
</tr>
<tr>
<td>CDCT5</td>
<td>3208</td>
<td>169.5</td>
<td>18.93</td>
<td>106.00</td>
<td>0.43</td>
</tr>
<tr>
<td>CDCT6</td>
<td>3208</td>
<td>171.5</td>
<td>18.71</td>
<td>104.00</td>
<td>0.34</td>
</tr>
<tr>
<td>CDCT7</td>
<td>3460</td>
<td>250.0</td>
<td>13.84</td>
<td>137.00</td>
<td>0.35</td>
</tr>
</tbody>
</table>