A Highly Integrated 8 mW H.264/AVC Main Profile Real-time CIF Video Decoder on a 16 MHz SoC Platform

Huan-Kai Peng, Chun-Hsin Lee, Jian-Wen Chen, Tzu-Jen Lo, Yung-Hung Chang, Sheng-Tsung Hsu, Yuan-Chun Lin, Ping Chao, Wei-Cheng Hung, Kai-Yuan Jan, Youn-Long Lin

Department of Computer Science
National Tsing Hua University
Our Contribution

• Highly integrated H.264 main profile decoder
• World-leading performance
  – CIF 45 fps @ 16MHz
  – 8mW @ 16MHz (core)
• FPGA Demonstrable
Multimedia SOC Platform

CPU
Accelerator (FPGA)
SDRAM (Ref)
USB (PHY)
ROM/SRAM Flash Memory
SDRAM
VIC
USB 2.0
Static Memory
SDRAM Controller (4-CH)
High Speed Bus
JPEG Codec DMA SRAM PWM WDT TIMER APB Bridge Capture Display Control
Peripheral Bus
DAI SSI SD SM UART GPIO I2C
Audio Codec I2S Flash Memory with SSI Flash Card Button LED Video-In CCIR601 TV/ LCD

THEDA DESIGN

YLLIN NTHU-CS
Proposed Video Decoder Architecture
External Memory Management

\[
2.9 + 40.5 + 26.1 + 30.4 + 1.6 + 1.6 + 9.5 = 112.7 \text{ (M cycle/ sec)}
\]

W/O MFU

\[
2.9 + 4.9 + 15.3 + 2.9 + 1.6 + 1.6 + 0 = 29.2 \text{ (M cycle/ sec)}
\]

W/ Straight-forward MFU

\[
2.9 + 1.6 + 5.1 + 1.1 + 0.2 + 1.6 + 0 = 12.5 \text{ (M cycle/ sec)}
\]

74 % reduction

89 % reduction

W/ Optimized MFU

Display buffer read
Reference frame write
SD Card to SDRAM
Display buffer write
SDRAM to input
Reference frame read
Non-overlapped decoding computation
<table>
<thead>
<tr>
<th>Gate Count</th>
<th>CPU with SW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Several M</td>
<td>[Vanghn Iverson, 2004]</td>
</tr>
<tr>
<td>238k gates</td>
<td>Proposed</td>
</tr>
<tr>
<td>10MHz</td>
<td>Required Frequency for CIF(352x288)</td>
</tr>
<tr>
<td>200K</td>
<td>Proposed</td>
</tr>
</tbody>
</table>

**Results and Comparison**

- **Hardwire [Guo, 2006]**
  - Frequency: 10MHz
  - Gate Count: 200K
  - Improvement: 5x

- **DSP [TI, 2006]**
  - Frequency: 200MHz
  - Gate Count: 20x improvement
  - Improvement: 20x

- **Proposed**
  - Frequency: 2GHz
  - Gate Count: 238k
  - Improvement: 20x and 5x
Demonstration System Status

<table>
<thead>
<tr>
<th>NTHU H.264 Main Profile Decoder System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
</tr>
<tr>
<td>Frame Rate</td>
</tr>
<tr>
<td>Clock Rate</td>
</tr>
</tbody>
</table>

![Demonstration System Status](image-url)
Thank You