Hardware Acceleration for CST MICROWAVE STUDIO®

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Channel Manager
1. Acceleware Overview
2. Why use Hardware Acceleration?
3. Current Performance, Features and Hardware
4. Upcoming Features and Hardware
5. Questions
### Processing Evolution

<table>
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<tr>
<th>Application Example</th>
<th>Application Size &amp; Complexity</th>
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<tbody>
<tr>
<td>Antenna</td>
<td>10 - 15 Years Ago</td>
</tr>
<tr>
<td>Cellphone</td>
<td>5 - 10 Years Ago</td>
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<tr>
<td>Head/Cellphone</td>
<td>Today</td>
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<tr>
<td>Full Body/Object</td>
<td>Tomorrow</td>
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<tr>
<th>Hardware Option</th>
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<tr>
<td>Supercomputer</td>
<td>Cluster</td>
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<td></td>
<td>PC</td>
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Value Proposition - Desktop

Accessible, Flexible Supercomputing Performance
At the Desktop
Value Proposition – Server Room

Same Budget, Large Leap in Performance
Quick Acceleware History

Highlights

- Feb 04  Founded
- Oct 05  Shipped First Product
- Jan 07  NVIDIA Invests US$2.5 Million
- Feb 07  $8 Million Private Placement
- Aug 07  50 Employees

Publicly-Traded: Toronto Venture Exchange (TSX), Symbol: AXE

1st Market: Electromagnetic (EM) – 6 announced partners; 2 new coming
2nd Market: Seismic – toward commercial launch Q4-07
3rd Market: Biomedical Imaging – 2008
**Why Acceleration?**

**Performance**
- Size of problem
- Time to solution
- Cost

*I*nter*mi*nite appet*ite for increased performance*
- Today … users *Compromise*
- Larger and more complex problems
  - Currently taking days, weeks, or longer to run
  - Computer-aided optimization

*Increased performance results in …*
- Faster time-to-market = Increased revenues
- Safer, better products = Reduced cost
- Better, more-informed decisions
Options for Acceleration

• What are the options for improving performance in the future?
  • CPU – central processing unit (ex. Intel Woodcrest)
  • FPGA – field-programmable gate array
  • GPU – graphics processing unit (ex. NVIDIA Quadro)
  • Cell – microprocessor architecture designed by Sony, Toshiba and IBM (ex. Playstation 3)
  • ClearSpeed – proprietary microprocessor architecture
  • Others – custom processors, ASIC, etc.
## Performance Comparison

<table>
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<tr>
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<th>Maximum Practical Speed</th>
<th>Maximum Size of Application</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>Multi-core</td>
<td>![Car Icon]</td>
<td>![RAM Icons]</td>
<td>![Dollar Icons]</td>
</tr>
<tr>
<td>FPGA</td>
<td>![Car Icon]</td>
<td>![RAM Icons]</td>
<td>![Dollar Icons]</td>
</tr>
<tr>
<td>GPU</td>
<td>![Car Icon]</td>
<td>![RAM Icons]</td>
<td>![Dollar Icons]</td>
</tr>
<tr>
<td>Cell</td>
<td>![Car Icon]</td>
<td>![RAM Icons]</td>
<td>![Dollar Icons]</td>
</tr>
<tr>
<td>ClearSpeed</td>
<td>![Car Icon]</td>
<td>![RAM Icons]</td>
<td>![Dollar Icons]</td>
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</tbody>
</table>

*Note: The above table compares various processing technologies based on performance, application size, and price.*

*Image Source: acceleware*
The Future of GPUs

- 2x memory bandwidth per year
- More cores
- 64-bit (‘double’ precision) support coming
Product Family for MICROWAVE STUDIO

**Accelerator™**
- Installs in your existing workstation (PCI-Express x16 slot)

**ClusterInABox™**
- Coming Soon!
- Two or four Accelerator cards
- Turnkey, Accelerator equipped workstation
Accelerator A30 Performance

• 1M – 24M meshcells fully accelerated
• >24M meshcells via Soft Memory Limit*
• ~7x speed up (referenced against a 4-core Woodcrest system running in software only)
• Speed up dependant on size rather than frequency

* Soft Memory Limit extends the maximum simulation size beyond that of the memory on the Accelerator by sharing memory with the host computer. Performance will depend on the proportion of memory shared.
Upcoming Hardware

ClusterInABox Dual D30 Performance

- Contains two Accelerator A30 cards
- 1M – 48M meshcells supported on hardware
- >48M meshcells supported in Soft Memory Limit
- \(~\textbf{12x speed up}\) (vs. typical software only run on a 4-core Woodcrest system)
• Accelerator A30 and ClusterInABox D30 are based on the NVIDIA Quadro FX chipset
• Leveraging the technology from consumer off the shelf products – you are getting the benefit of the highest end products from NVIDIA, developed for the video game and graphics industries
• Accelerator A30 card has 128 cores and 90 GB per second of bandwidth
• GPUs are well suited to parallel problems, such as electromagnetic simulations, because of large bandwidth and vectorized operations
MICROWAVE STUDIO and Acceleration

- The Accelerator A30 card(s) is used during the transient analysis portion of the simulation run.

- The Accelerator does not speed up the setup and matrix calculation time.

- The calculations normally done on the CPU are transferred to the Accelerator A30 – this is handled within MICROWAVE STUDIO.
Currently Supported:
  • Windows ® XP (32-bit)
  • Windows XP 64-bit (strongly recommended)

Future Supported:
  • Red Hat Enterprise Linux® WS 4
  • Windows Vista™
Within the **Transient Solver** of MICROWAVE STUDIO, the following types of simulations up to 24M meshcells (for one Accelerator A30) will be best suited to hardware acceleration:

1. Printed circuit boards with closed boundaries.
2. Connectors with closed boundaries.
3. Cables with closed boundaries.
4. Packaging with closed boundaries.
5. Open boundaries (requires MWS 2008).
Currently Supported Features

Features Supported by hardware acceleration:
• TST (thin sheet technology)
• SIBC (surface impedance boundary condition, ie. Lossy metal model)
• Closed boundaries (PEC walls, PMC walls)
• Subcycling
• Lossless and lossy heterogeneous dielectric materials
• Open boundaries (MWS 2008)
• Near to far field monitors (MWS 2008)
Benchmarks – IC Package Example

Accelerator A30 Performance  ClusterInABox D30 Performance

Note: Above speed up factors are determined by comparison to a 4-core Woodcrest system.
IBM Challenge Problem

Size of Model: 27 million meshcells
Shape:  X: 677  Y: 1159  Z: 36

Calculation times:

<table>
<thead>
<tr>
<th></th>
<th>Model run in Software Only</th>
<th>Model run on a ClusterInABox D30</th>
<th>Speed Up Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solver Time (hrs)</td>
<td>273.8</td>
<td>18.4</td>
<td>14.9</td>
</tr>
<tr>
<td>Total Run Time (hrs)</td>
<td>276.2</td>
<td>20.0</td>
<td>13.8</td>
</tr>
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Accuracy and Stability of Hardware Acceleration

- Both GPU and CPU are 32-bit floating point precision
- Order of operations and rounding are slightly different between the two
- However, time domain results are virtually identical
Hardware Acceleration will continue to be supported in MICROWAVE STUDIO 2008 and beyond.

Future Features:

- Red Hat Enterprise Linux
- Windows Vista
- “40 Series” Hardware
- Dispersive Models
- Periodic Boundaries
THANK YOU

Questions?