Gedae Portability: From Simulation to DSPs to the Cell Broadband Engine

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HPEC 2007: Multicore Processors and Their Impact on DoD HPEC Systems
The Software Architecture Makes Hardware Refreshes Difficult

Old System

PE-0
Code 0

PE-1
Code 1

PE-2
Code 2

PE-3
Code 3

New System

PE-A
Code A

PE-B
Code B

PE-C
Code C

PE-D
Code D

PE-E
Code E

PE-F
Code F
Problems that Reduce Software Portability

- Languages and compilers are based on serial processors
- Software architecture is buried in the code
- Differences in multiprocessor/m multicore hardware necessitate changes to the software architecture
  - Number of processors
  - Interconnection
  - Bandwidth
  - Processor speed
  - Memory size
  - Memory structure
- Gedae mitigates the risk of porting software by automating the incorporation of the software architecture

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Application Environment

- Search and track using four audio channels
- Display using camera directed by pan-tilt unit
Stages in Development

1. Developed as simulation with file input and rendered output
2. Deployed on quad PowerPC board, processing in real time at limited frame rate
3. Hardware refresh to Cell Broadband Engine processor, processing more frames per second
## System Specifications

<table>
<thead>
<tr>
<th></th>
<th>Simulation</th>
<th>Mercury AdapDev</th>
<th>Playstation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processors</td>
<td>1</td>
<td>4 PowerPC AltiVec (500 MHz), 1 Pentium</td>
<td>1 PPE, 6 SPEs</td>
</tr>
<tr>
<td>Sensors</td>
<td>Datafile of 4 recorded channels</td>
<td>ICS 610 ADC PCI Board, 4 microphones</td>
<td>M-Audio Quattro USB Device, 4 microphones</td>
</tr>
<tr>
<td>Output</td>
<td>Constellation display</td>
<td>Directed Perception D46-17 Pan-Tilt Unit</td>
<td>Directed Perception D46-17 Pan-Tilt Unit</td>
</tr>
<tr>
<td>UI</td>
<td>Rendered scene</td>
<td>Matrix Vision BlueFOX USB Camera displayed using Video for Gedae</td>
<td>Matrix Vision BlueFOX USB Camera displayed using Video for Gedae</td>
</tr>
</tbody>
</table>
Algorithm Specified in Gedae

Low Pass Filtering

Pan and Tilt Camera

4 Channel Audio Input

Correlate the 4 Channels

Detection Algorithm

Same flow graph used for simulation, quad DSP board, and Cell/B.E. processor

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Simulation Using Gedae-Sim

- Audio data captured from actual model train, recorded to file
- Simulated 3-d environment created with train, track, camera, and light
- Scene rendered from vantage-point of camera
- Gedae-Sim used to verify algorithm and run on multiple virtual processors

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Mercury AdapDev

- Pentium III development host
  - 1.26 GHz
  - 1 GB SDRAM
- Quad PowerPC 500MHz (MCP7410)
  - AltiVec instruction set
  - 2 MB L2 cache
  - 256 MB SDRAM
  - DMA engines
- RACE++ switched-fabric architecture

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### Map partitions to 4 PowerPCs
- Preprocess 4 channels in 4 partitions.
- DMA between processors.
- Nonblocking transfer of audio data from host to PowerPCs.
- Strip mine for cache performance.
- Add Correlation to 0-th partition.
Cell/B.E. Architecture

- Power Processing Element (PPE)
- 8 Synergistic Processing Elements (SPE)
  - VMX SIMD instruction set
  - DMA engines
  - 256 kB Local Storage (LS)
- System Memory
- Element Interconnect Bus (EIB)
  - Over 200 GB/s

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Cell/B.E. Implementation

- Alter implementation to use 6 SPEs
- Alter implementation to fit in the SPEs’ 256KB Local Storage
- Maximize use of SPEs

- Put Preprocessing of 4 channels in 4 partitions
- Strip mine to reduce memory footprint
- Map partitions to 6 SPEs
- Use 2 SPEs to perform 1st stage of correlation
**Results**

- Gedae was used to easily move the application to new hardware
- Changes to the implementation were handled by automation and simple GUIs, not changes to code
- High performance gains were realized with minimal effort

<table>
<thead>
<tr>
<th>Target</th>
<th>Programmer Hours</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation</td>
<td>4 weeks</td>
<td>-</td>
</tr>
<tr>
<td>Mercury AdapDev</td>
<td>6 hours</td>
<td>3 Hz</td>
</tr>
<tr>
<td>Cell/B.E.</td>
<td>2 hours</td>
<td>15 Hz</td>
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