6.189 IAP 2007

Student Project Presentation

Software Radio
Flexible Stream Processing
On the Cell

Case Study: Software Radio

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Motivation

- Cell isn’t easy to program
  - No shared mem, messy msg passing

- Extracting parallelism is nontrivial
  - E.g., pipelining can be quite tricky

- Stream programming (as discussed) can help address both issues
What We Built

- Lightweight, but expressive streaming framework targeted at DSP apps
  - Data model based on WaveScope streaming DBMS

- Case study:
  - Simple Software Radio (Incoherent ASK)

- Main Goals:
  - Simplify life for developers
  - Automate as much parallelism as possible
Programming Model

- Basic execution unit is the “operator”
  - Analogous to StreamIt work fn, or GNURadio block

- Can be arbitrary C++ classes, with state
  - Overload iterate() to process block of data

- Apps built by chaining operators:
  CREATE_BOX(FIRFilter<float>, filter1, args…)
  CREATE_BOX(WhiteNoiseGen, noisegen, args…)
  CONNECT(filter1, noisegen)
  ....
Framework Components

- Lightweight Scheduler on PPE and SPEs
  - Static operator mapping to SPEs, but easy to extend

- Signal Blocks (adapted from WaveScope)
  - Ref counting, avoid in-memory copies
  - Convenient API, with “append” and “subseg”

- Queue, and remote heap mgmt library for Cell
  - Automatic pipelining for streaming, SPE-SPE
  - Autonomous memory mgmt (not PPE controlled)
S/W Radio Implementation

- Simple prototype to evaluate framework
- 25 Operators, mapped to PPE + 5 SPEs
- ~3K lines of code (2K framework, 1K radio)
S/W Radio (Contd.)

- Simulated Channel
  - Random FIR Filter (emulate multipath)
  - Additive Gaussian white noise

- Simple ASK modulation

- Incoherent demodulation (quick and dirty)
Example Decoded Waveform
Challenges

- Distributed, almost zero-copy objects
- Lock-free remote heap for streaming data
- Low code footprint on SPE
- Efficient scheduling, SPE-SPE flow control
- Race conditions and memory corruption
  - Not completely solved yet 😞
Prelim Results (S/W Radio)

<table>
<thead>
<tr>
<th># of Processors Used</th>
<th>Throughput (-O2) (x1000 samples/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Only PPE)</td>
<td>~ 170</td>
</tr>
<tr>
<td>6 (1 PPE + 5 SPEs)</td>
<td>~ 640</td>
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Speedup with max #SPEs ~ 4
Code footprint of framework ~ 75K
Issues and Bottlenecks

- Flow control not completely resolved
  - PPE spends 50% of its time blocked for SPE queues to drain

- Code footprint needs further reduction
  - Restricts queue sizes, worsens flow problem
Future Work

- Reduce code footprint
- Use framework to investigate dynamic/static operator → SPE assignment algorithms
- Automatic data parallelism
  - Run same op in parallel
- Build more apps for Cell using framework
Project Summary

- Dynamic, flexible streaming framework
- Convenient for DSP apps
  - Block passing abstraction
- Reasonably scalable (Pipeline parallelism)
- Lots of work remains…