Buffer-space Efficient and Deadlock-free Scheduling of Stream Applications on Multi-core Architectures

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Background – Stream Compilers
Model of Computation – Synchronous Data Flow (SDF)\(^1\)
- Actors: computation
- Streams: communication
- Many embedded apps.
- Deterministic parallelization
- Efficient communication through DMAs

Two important phases
- Partitioning: e.g., map A and B to core 0, C to core1
- Use METIS or integer linear programming
- Scheduling

Scheduling – Previous Work
Stream graph modulo scheduling (SGMS)\(^2\)

Previous Work – Drawbacks
Buffer-space Explosion: e.g., W-CDMA
Feedback Loops: e.g., GSM
- Contract feedback loops to single actors, and loose parallelism, or
- Suffer deadlocks.

Team Scheduling\(^3\)

if (!cin0.isEmpty() && !cout0.isEmpty()) {
  doB();
}
if (!cin0.isEmpty() && !cout0.isEmpty() && !cout0.isEmpty()) {
  doC();
}

if (!cin0.isEmpty() && !cout0.isFull()) {
  doB();
}
if (!cin0.isEmpty() && !cout0.isEmpty() && !cout0.isFull()) {
  doC();
}

if (!cin0.isEmpty() && !cout0.isFull()) {
  doB();
}
if (!cin0.isEmpty() && !cout0.isEmpty() && !cout0.isFull()) {
  doC();
}

Buffer sizing
Producer-consumer Pairs

Team formation
Inter-team synchronization elimination

if (!cin1.isEmpty() && !cout0.isFull()) {
  doB();
}
if (!cin1.isEmpty() && !cout0.isEmpty() && !cout0.isFull()) {
  doC();
}

if (!cin1.isEmpty() && !cout0.isFull()) {
  doB();
}
if (!cin1.isEmpty() && !cout0.isEmpty() && !cout0.isFull()) {
  doC();
}

Results

- Evaluation Setup
- StreamIt benchmarks, GSM, and W-CDMA
- 16-core ELM \(^4\)
- ELK stream programming language \(^5\)

- Buffer-space Limited Experiment
- SGMS cannot satisfy the buffer limit for W-CDMA (16-128KB), fft (16-64KB), gsm (16-32KB), mpeg (16KB), and vocoder (16KB)
- Average speedup of team128KB is 11x
- 37% higher throughput

- Amortization Factor Limited Experiment

References
\(^2\) Manojit Kundur and Scott Mahlke, Orchestrating the Execution of Stream Programs on Multicore Platforms, PLDI, 2008
\(^3\) Jongsoo Park and William J. Dally, Buffer-space Efficient and Deadlock-free Scheduling of Stream Applications on Multi-core Architectures, SPAA, 2010
\(^5\) ELK webpage, CVA Group, Stanford University.
http://cvapluseum/projects/elk

\(\text{ax3} x \text{bx3} \)