Task Superscalar: an out-of-order task pipeline

Advanced Computer Architectures

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What is Task Superscalar?

Task superscalar multiprocessors are a task-level abstraction of dynamically scheduled out-of-order processors that manages cores as functional units.
Why task superscalar?

- Out-of-order pipeline is fast in decoding operation
- Compiler finds parallel instructions far from each other
- Task superscalar decode operation at same speed of pipeline execution but finds many more parallel instruction w.r.t. it
Decode rate (I)

Classic pipeline: decode instruction in the first phase, within 1 clock cycle

Task superscalar: decode a task (group of instructions) depending on its execution time

As result, pipeline timing is relaxed as granularity (# of operation considered) grows
Decode rate (II)

\[ T = \text{task runtime} \]
\[ P = \# \text{ of processors} \]
\[ R = \frac{T}{P} \]

Ex:
- ILP: \[ T = 1 \text{ cy.}, \quad P = 2 (FU) \] yields \( R = 0.5 \text{ cy.} \)
- Task-level (fine): \[ T = 256 \text{ cy.}, \quad P = 256 \] yields \( R = 1 \text{ cy.} \)
- Task-level (medium): \[ T = 50K \text{ cy.}, \quad P = 256 \] yields \( R \approx 200 \text{cy.} \)
- Task-level (coarse): \[ T = 1M \text{ cy.}, \quad P = 256 \] yields \( R \approx 4000 \text{ cy.} \)
From instruction to task decode

- exposing task effects on shared state: task operands consists of memory objects and scalar values; they are represented as tuples consisting of \(<\text{operand type}, \text{base pointer}, \text{object size}, \text{directionality}>\)

- decoding tasks \textit{in-order}: this is necessary to preserve producer/consumer relationship, and is unsurprising since the thread that generates a task is itself sequential
Task superscalar frontend

Superscalar equivalents:
- Register Renaming Table
- Physical Register File (meta-data only)
- Reservation Stations

Diagram:
- ORT
- OVT
- TRS
- Ready Queue
- NoC
- Pipeline Gateway
- eDRAM
- Controller
Evaluation

- impact on the decode rate
- impact on the window size
  - ORT/OVS size
  - TRS size
- decode rate vs. window size