Reducing Power with A Dynamically Reconfigurable Issue Queue

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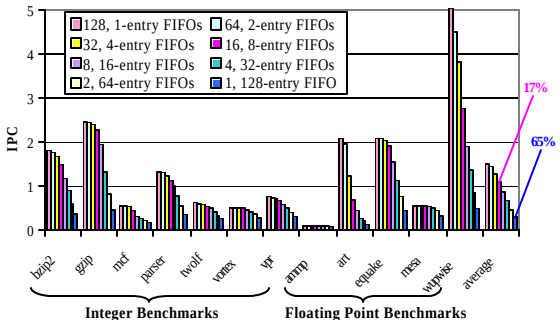
Motivation

- Performance and power trends
  - Many complex architectural features are included
  - These features consume power regardless of usage
- Adjustable datapath resources to match the application's needs
- Focus on issue logic since it consumes a large portion of overall power dissipation
  - For instance, it was projected that the 21464 issue logic would account for 46% of the total power

The FIFO Approach

- Proposed by Palacharla & Smith [ISCA 97]
- Fixed number and size of FIFOs
- Combined in-order & out-of-order issuing
- Dependent instructions are inserted into a single FIFO
- Instructions are issued from FIFOs in parallel
- Only the instruction at the head of each FIFO is visible to the arbitration logic

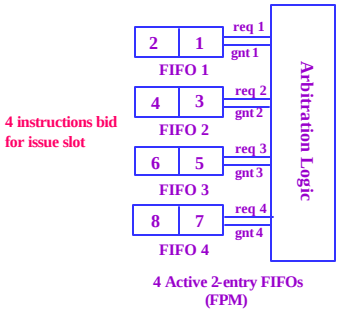
Fixed-sized FIFOs



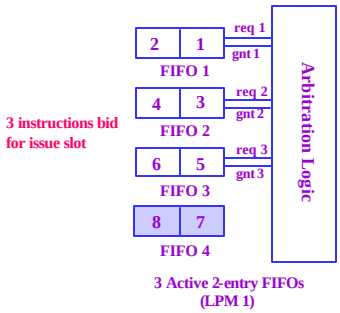
Limitations of Fixed FIFO Scheme

- A single configuration works well for some benchmarks, but not for others
- High ILP: use more, or smaller FIFOs
- Low ILP: use few FIFOs
- Change number and size of FIFOs dynamically according to program needs

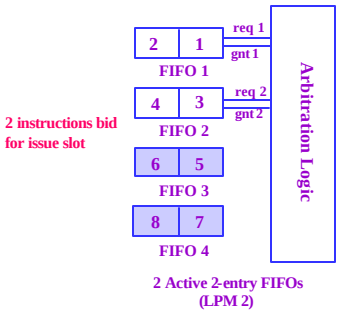
Scheme 1: variable number of FIFOs



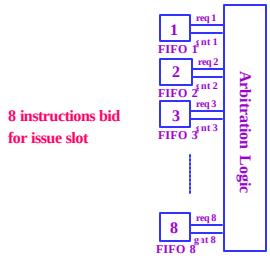
Scheme 1: variable number of FIFOs



Scheme 1: variable number of FIFOs

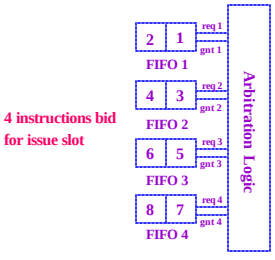


Scheme 2: variable sized FIFOs



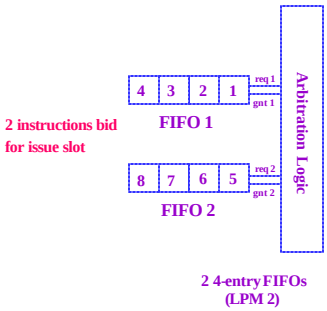
8 1-entry FIFOs (FPM)

Scheme 2: variable sized FIFOs



4 2-entry FIFOs (LPM 1)

Scheme 2: variable sized FIFOs



2 4-entry FIFOs (LPM 2)

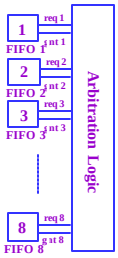
Scheme 1 *vs*. Scheme 2

- Scheme 1
  - Easier to implement
  - Save more power
  - Larger performance loss
- Scheme 2
  - Harder to implement
  - Save less power
  - Smaller performance loss

→ **Combine Scheme 1 and Scheme 2**

Hybrid Scheme: Scheme 1 + Scheme 2

8 instructions bid for issue slot

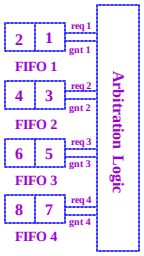


8 1-entry FIFOs (FPM)

Start from a traditional issue queue as Scheme 2

Hybrid Scheme: Scheme 1 + Scheme 2

4 instructions bid for issue slot

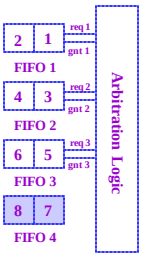


4 2-entry FIFOs (LPM 1)

Apply Scheme 2 until reaching MAX_FIFO_SIZE

Hybrid Scheme: Scheme 1 + Scheme 2

3 instructions bid for issue slot



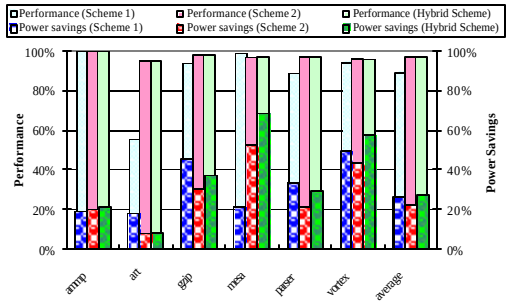
3 2-entry FIFOs (LPM 2)

Then apply Scheme 1

How Do We Decide When to Switch?

- Assumption: short term past behavior is a good indicator of behavior in the near future
- How do we keep track of "program needs"?
  - Keep track of statistics while a program is running
- Help decide the optimal configuration
- We use an array of monitors

Experimental Results



Conclusions

- Issue queue is a major contributor to power
- Flexible schemes so we do not hamper performance
- Dynamically reconfigurable, FIFO-structured issue queue can save power with negligible performance impact