Reducing Design Complexity of the Load/Store Queue

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What is a Load/Store Queue?

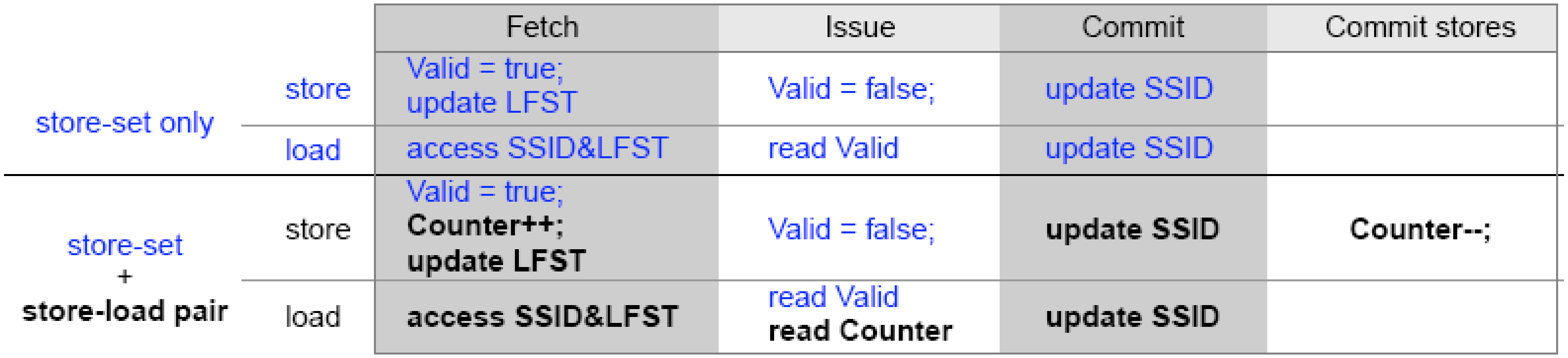
- Two separate queues
  - Load Queue
  - Store Queue
- Functions
  - Buffer and maintain all in-flight memory instructions in program order
  - Support associative searches to honor memory dependence
  - Support associative searches to enforce memory consistency

Scaling techniques

- Reduce search bandwidth demand
  - Store queue
    - Store-set predictor
  - Load queue
    - Load buffer holds all out-of-order-issued loads
- Increase queue capacity
  - Segment Load/Store queue into multiple smaller queues and chain them together

Reducing Store Queue Search

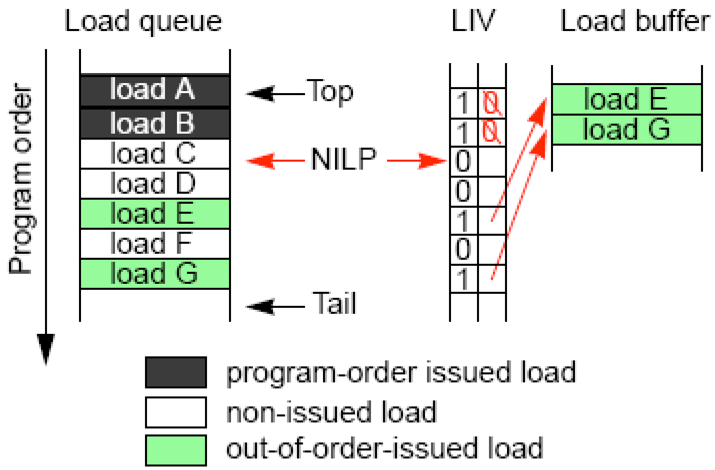
- Motivation
  - If we can predict that a load will not find any matching store, we can avoid performing useless store queue search
- Solution - Store-set predictor
  - Have a counter keep track of all non-committed stores
  - If counter
    - larger than zero, load must search the store queue
    - zero, load obtains value from cache hierarchy



		Fetch	Issue	Commit	Commit stores
store-set only	store	Valid = true; update LFST	Valid = false;	update SSID	
	load	access SSID&LFST	read Valid	update SSID	
store-set + **store-load pair**	store	Valid = true; **Counter++;** **update LFST**	Valid = false;	**update SSID**	**Counter--;**
	load	**access SSID&LFST**	read Valid **read Counter**	**update SSID**	

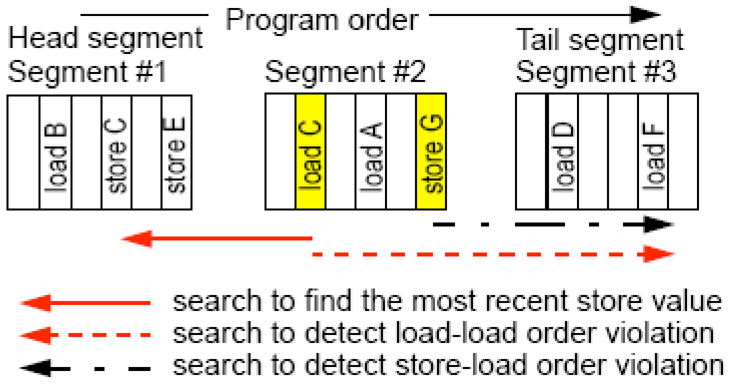
Reducing Load Queue Search

- Motivation
    - Average number of out-of-order loads is small, so why search Load Queue *every* time
- Solution – Load Buffer
    - Keep out-of-order-issued loads separate from Load Queue
    - When load issues
        - Oldest non-issued load
            - Search Load Buffer
        - Else
            - Copy load address into Load Buffer



Increasing Queue Capacity

- Motivation
  - If you *have to* search, search less if possible (not really sure about this)
- Solution - Segmentation
  - Instruction performs dependence search on its segment first
  - If no match, continue to next segment
- Allocation strategies
  - *no-self-circular* - many segs
  - *self-circular* - compact



Results

- Set-predictor
  - Reduces search bandwidth demand 67%(int), 76%(float)
- Load buffer
  - Reduces search bandwidth demand 74%(int), 77%(float)
- Set-predictor + Load buffer
  - Average speedup 2%(int), 7%(float)
- Segmenting the load/store queue
  - Self-circular outperforms no-self-circular

- Combining it all
  - Average speedup 6%(int), 23%(float)

Questions

- The improvement provided by segmentation is not that impressive. Can it be further enhanced?
- How many ports do today’s load/store queues have?
- Is it still expensive to build multi-port load/store queue?
- Could we adaptively increase or decrease the aggressiveness of our predictors according to their success?
- What would be the effect of fewer hardware guarantees that put more pressure on the software/compiler writers to guarantee that mis-ordering errors will never happen? Would “delay” slots need to be inserted or could they do better?
- How do you decide the benchmark to evaluate the architecture?
- Only two benchmarks are used in the simulation. Do we still have improvements if we use other types of benchmarks?
- If it’s possible that a new approach works well in some benchmarks in experiment, but not well for some others? How to deal with this case?