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Cache Coherence Simulations

MSI

The MSI protocol contains three states. Modified, Shared, and Invalid. The advantage of write back caches over the writethrough caches is the amount of bandwidth used between caches and main memory. The maintainance of a dirty state allows the cache to buffer data until it is ready to be written back. The serious drawback of the MSI protocol is when a processor wants to read and write to a processor exclusively.

MESI

The Modified, Shared, Invalid, and Exclusive states of the MESI protocol allow a processor to hold access to a cache block exclusively. A major drawback of MESI protocol is that it only provides for clean sharing. When another processor requests access to cache block the data must be written back to main memory. In this way every cache that obtains the data has a clean copy. Since bandwidth resources to main memory are limited and adds latency there is a way to share dirty data among the cache blocks without access to main memory. To illustrate this we observe that in the output of Cache 2 from the 'CGad' trace file we have:
Four cache to cache transfers with MSI and sixty-nine cache to cache transfers in the MESI protocol. There are 141 'Invalid' to 'Shared' transitions with MSI, while there are 69 in the MESI protocol. There are many for 'Invalid' to 'Exclusive' in the MESI protocol. This also illustrates that with the addition of an exclusive state there are contention problems.

MOESI

Maintaining an owner state within each cache block reduces contention among caches from different processors. Each cache knows when to flush the data. This in combination with dirty sharing reduces access to main memory, in turn reducing latency.

To get a better understanding of the overall impact one must also account for costs of accessing main memory. An example is the following:

- A hit to the local cache results in a cost of only 1.
- A cache to cache transfer may cost 20.
- And the most expensive of all data transfers is access to the main memory which can easily be two fold at 40.

By adding up these costs in the coherence counters one observes in the simulation it is apparent of the cost savings of the MESI protocol.