ECE 4100 – Yingyan Wang – Cache Coherence Experiments

Different cache coherence protocols result in different run time because of different number of memory accesses, cache transfers, and overall memory access performance. Table 1 and Figure 1 below summarizes the run time performance of 8 experiments in total for each of the five protocols (MSI, MOSI, MESI, MOESI, MOESIF).

Protocol Run Time / Experiments	MSI (cycles)	MOSI (cycles)	MESI (cycles)	MOESI (cycles)	MOESIF (cycles)
Experiment 1	317	217	317	217	217
Experiment 2	2367	1167	2267	975	683
Experiment 3	3723	3723	2607	2607	1425
Experiment 4	2265	1869	1447	851	551
Experiment 5	1661	1261	1561	1161	461
Experiment 6	7775	6975	4925	4125	3125
Experiment 7	6459	5359	3993	2909	2909
Experiment 8	9477	8477	6441	5241	4141

Table 1. Run time cycles of each protocol for experiment 1 – 8.

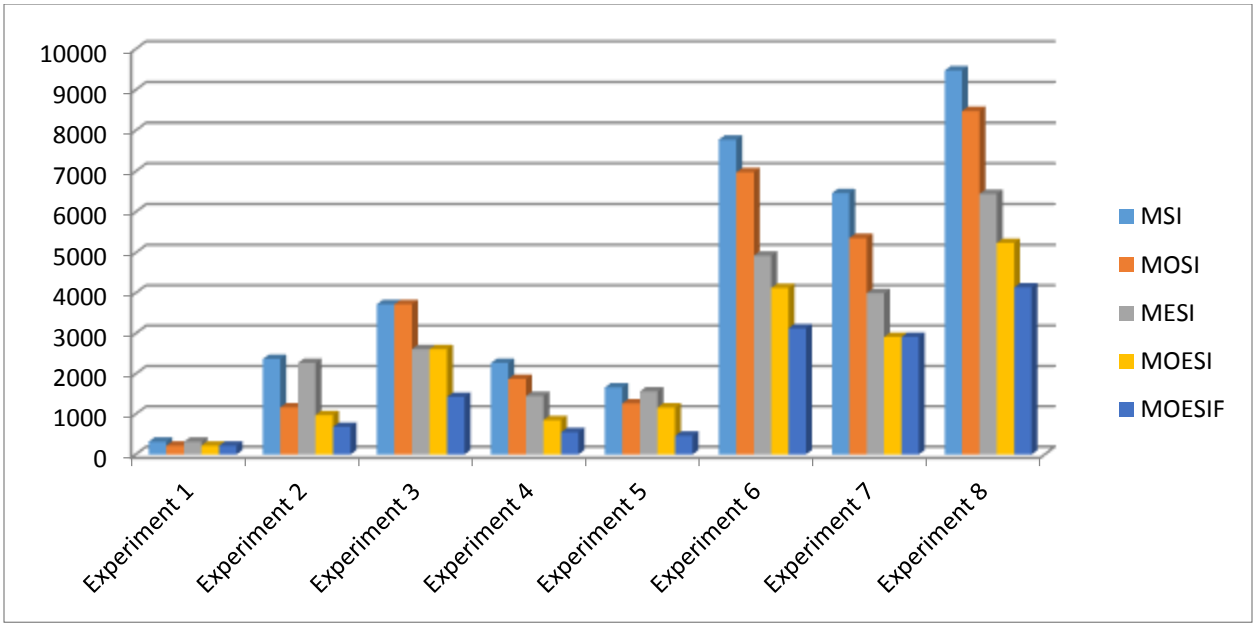

Figure 1. Run time for each protocol vs. Experiments Summary.

Experiment 1.

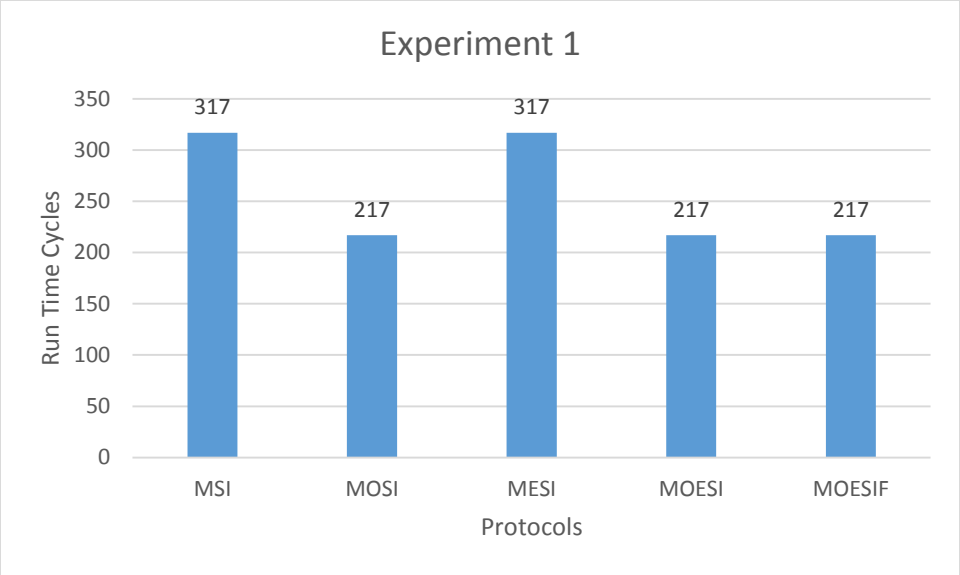

Figure 2. Result for Experiment 1.

For experiment 1, MOSI, MOESI, and MOESIF all tie in performance, requiring 217 cycles to complete. The MSI and MESI come the second, with 317 cycles.

MOSI protocol is recommended for this experiment, because it has the lowest execution time, as well as the least amount of states required.

The lower performance in the MSI and MESI protocols is because they do not have the Owner state, which supports more cache to cache transfer. Because less cache to cache transfer is allowed in MSI and MESI state, they require more memory transfer, which increases execution time greatly.

Experiment 2.

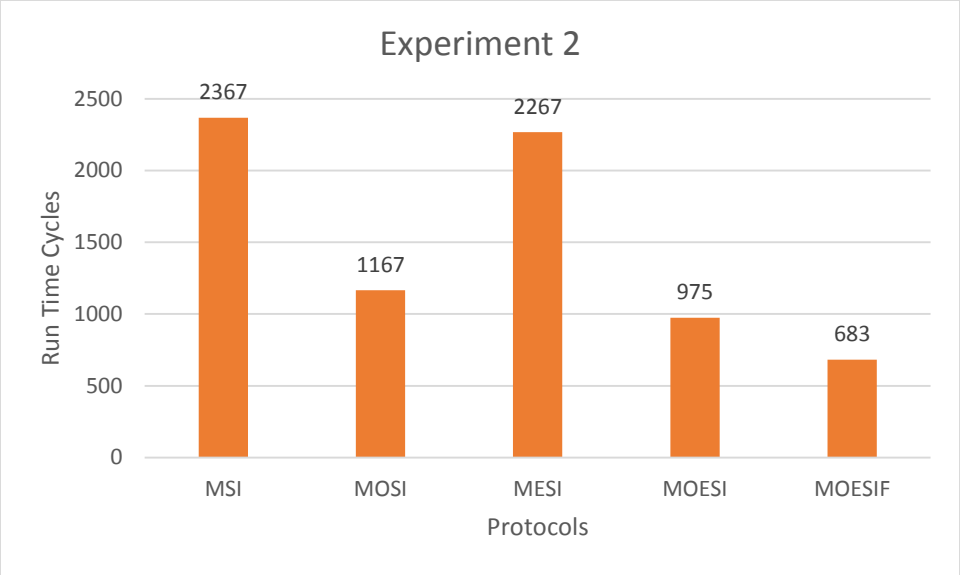

Figure 3. Results for Experiment 2.

For experiment 2, the MOESIF has the best performance, with an execution time of 683 cycles. The MSI protocol has the worst performance, as it requires 2367 cycles to execute. Therefore, the MOESIF protocol is recommended because of its least execute time.

The MOESIF consists of the F state, which allows the ability of cache to cache transfer, when downgrading from the E state. The MOESI protocol has more memory accesses than the MOESIF protocol, and less cache to cache transfer, therefore, the memory accesses become the bottleneck of its performance. The MOSI protocol requires more memory accesses due to the lack of the E state. Furthermore, because MESI and MSI don't have the O state, they both have a lot more memory accesses, resulting in far worse performance than the other protocols. The MESI protocol is slightly better than the MSI protocol, because of the E state, which allows silent upgrade and reduce memory access.

Experiment 3.

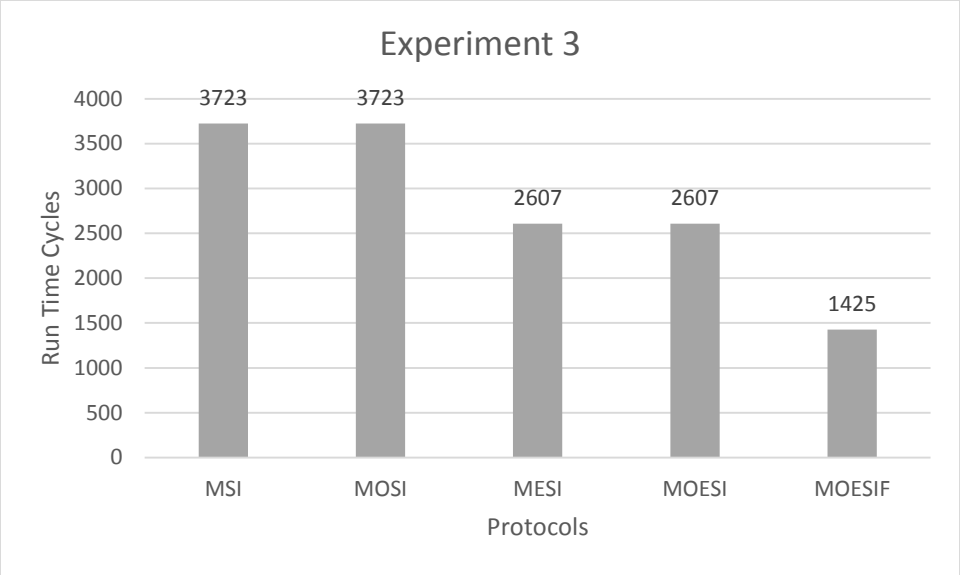

Figure 4. Results for experiment 3.

For experiment 3, the MOESIF protocol has the best performance of 1425 cycles of execution time. The MSI and MOSI protocols come the second, with 2607 cycles of execution time. The MSI and MOSI have the worst performance, with 3723 cycles to execute.

Therefore, the MOESIF is recommended.

The performance of MSI and MOSI are significantly worse than the other protocols, because they do not have the E state. Both protocols cannot silently upgrade to the M state, resulting in more memory transfers. Both MESI and MOESI have worse performance than MOESIF, because they do not have the F state, and have less cache to cache transfers than MOESIF.

Experiment 4.

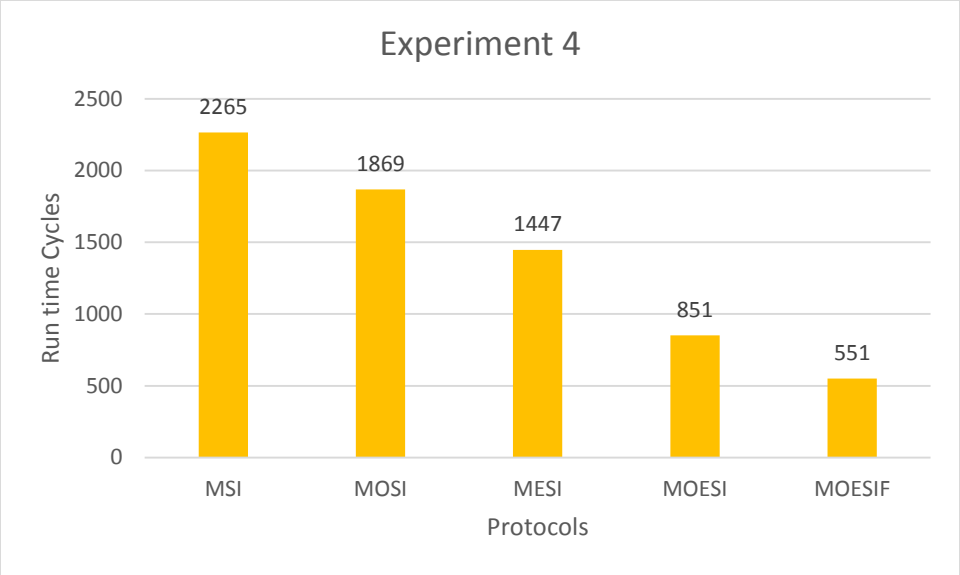

Figure 5. Results for experiment 4.

For experiment 4, the MOESIF protocol has the best performance of 551 cycle execution time. The MSI protocol has the worst performance of 2265 cycle execution time. Therefore, the MOESIF protocol is recommended.

This experiment results in the performance of MOESIF > MOESI > MESI > MOSI > MSI.

The MOESIF has better performance than MOESI because of its F state that allows more cache to cache transfers than MOESI. MOESI is better than MESI because of its O state, which allows more cache to cache transfer than the MESI protocol. The MOSI protocol has similar amount of cache to cache transfer as the MOESI protocol, but it lacks the E state, therefore unable to silently upgrade to M state. This result in more memory accesses and cache misses for the MOSI protocol. The MSI has the worst performance because it does not include E, O, F state, therefore having the least ability for cache to cache transfer, and does not support silent upgrade to the M state.

Experiment 5.

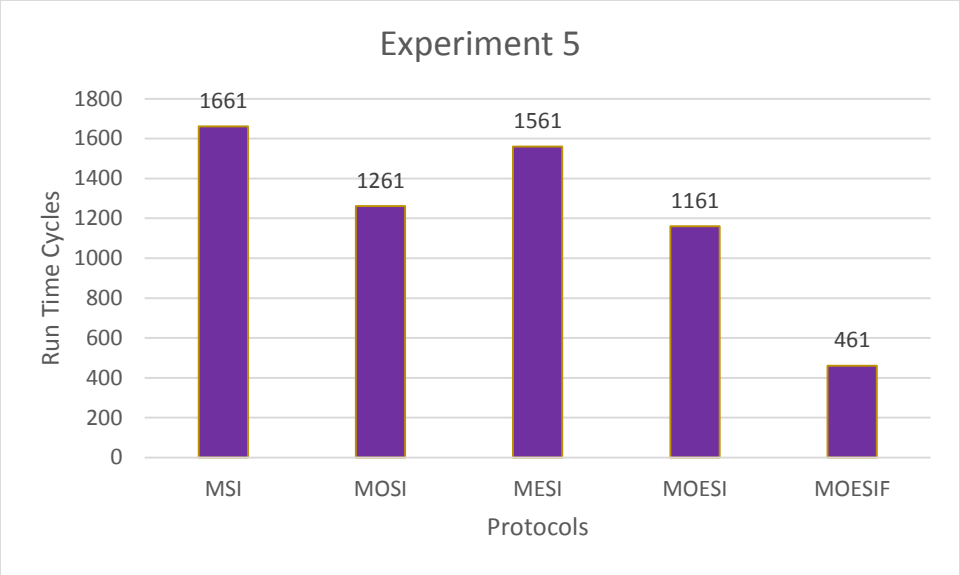

Figure 6. Results for experiment 5

For experiment 5, the MOESIF protocol has the best performance of 461 execution cycles. The MSI protocol has the worst performance, with 1661 cycles.

The MOESIF is recommended for this experiment.

The MOESIF has significantly better performance than MOESI because of its F state that allows more cache to cache transfers than the MOESI protocol. The MOESI protocol has slightly better performance than the MOSI protocol because of the E state, that allows silent upgrade to M state, but in this experiment, the advantage is not fully recognized. In this experiment, the inclusion of O state allows for significant improvement on performance. The MESI protocol has worse performance than the MOESI protocol because of the lack of O state, resulting in more memory accesses, which increase the execute time largely. The MSI has the worst performance, because it has only three states, and much more memory accesses than the other protocols, due to the lack of ability for cache to cache transfer.

Experiment 6.

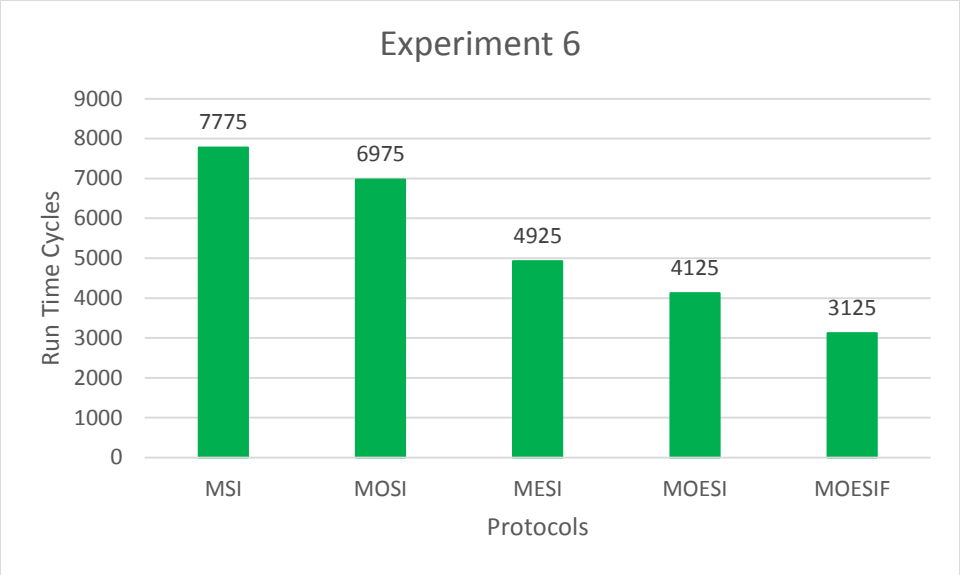

Figure 7. Results for experiment 6.

For experiment 6, the MOESIF is the recommended protocol because of its least execution time of 3215 cycles, and the MSI has the worst performance of 7775 cycles of execution time.

The MESI and MOESI come relatively close to the MOESIF, while MOSI and MSI have much worse performance. This is because this experiment has a large amount of silent upgrades, and the protocols with the E state has the advantage over the ones that don't. However, the MOESI and MESI protocol is still worse than the MOESIF, when it comes to performance, because they still have more memory accesses than the MOESIF protocol.

Experiment 7.

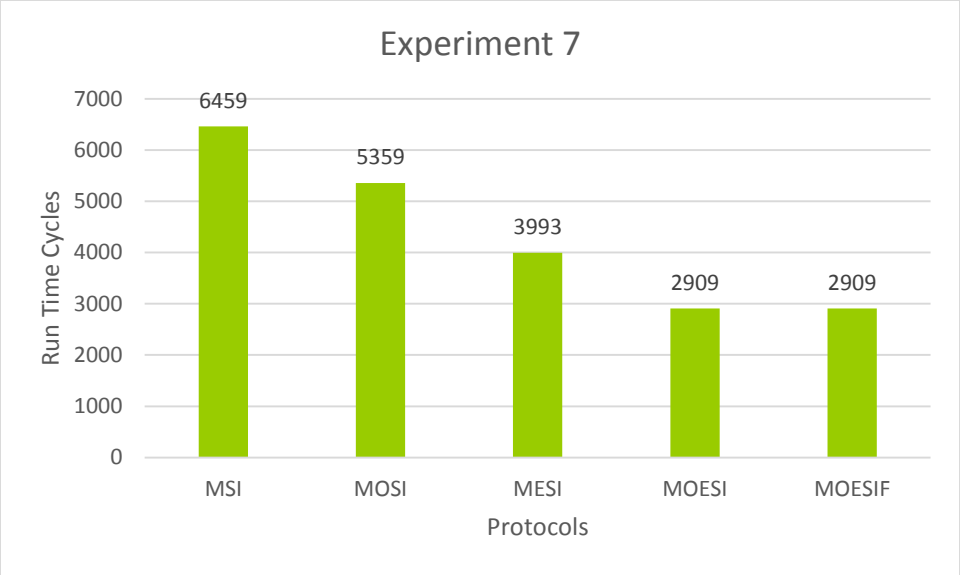

Figure 8. Results for experiment 7.

For experiment 7, the MOESI and MOESIF protocols both have the best performance of 2909 execute cycles. The recommended protocol is MOESI, because it requires one less state than MOESIF.

The advantage of inclusion of the F state is not shown in this experiment, and the number of cache to cache transfers have limited impact on performance. The MESI has worse performance because it does not have the O state, and it has less cache to cache transfers than MOESI and MOESIF. The MOSI protocol is even worse than the MESI protocol. The MOSI has the O state, which allows for more cache to cache transfers, however, it cannot upgrade silently to M state, and in this experiment, including the E state has a larger advantage due to the large amount of silent upgrade. The MSI protocol still comes the worst.

Experiment 8.

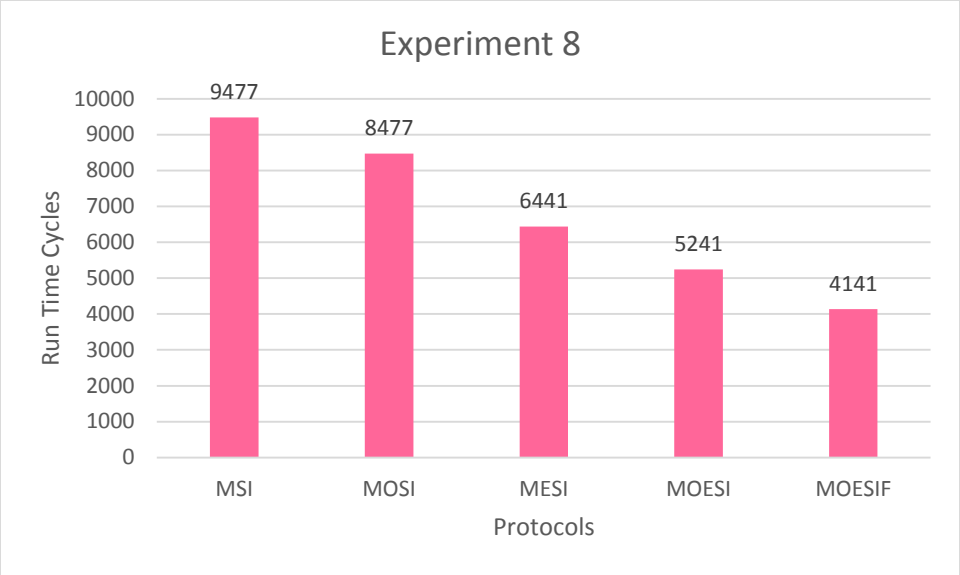

Figure 9. Results for experiment 8.

The MOESIF is the recommended protocol due to its performance of 4141 cycles, and the MSI has the worst performance with 9477 cycles.

The MOESI has worse performance than MOESIF because it has less cache to cache transfers, as it does not have the F state. The MOESI has better performance than the MESI protocol because of the O state, allowing for more cache to cache transfers. At the same time, the discrepancy between MOESI and MOSI is even larger, because the MOSI lacks the E state, and this experiment has an amount of silent upgrade, that the MOSI state cannot perform. This experiment has more silent upgrades than access that take advantages of the O state, and the E state plays a relatively larger role than the O state. The MSI still comes the worst, because of its limited states.