

ECED 3403 Computer Architecture Assignment 2 Testing Report

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<https://github.com/weakbox/eced3403-emulator>

Test 1: Basic Cache Test (Direct-Mapping)

Setup: The provided “cache_basic.asm” assembly file was assembled using the most recent version of the provided XM-23 assembler. The resulting .xme file was then run using the XM-23 emulator. The emulator cache was set to direct mapping mode.

Expected Results: The cache should be completely filled with addresses from the IR. There should be no reported usage values as we are using direct mapping.

Results: The cache was correctly filled with addresses and instructions from the IR. We can see that the 49th instruction (0000 at address 1060) has been placed in cache line 16. This is correct, as from the direct mapping cache algorithm:

$$\frac{\text{address}}{2} \% 32 = \text{index}$$

$$\frac{1060}{2} \% 32 = 16$$

The index is indeed 16.

```

C:\Users\conno\Desktop\XM-23Emulator\x64\Debug\XM-23 Emulator.exe
R7: 1062 (PC)  C7: ffff
Clock: 294
Input: 8
Printing 32 cache lines...
00: 1040 4088 00 0
01: 1042 4088 00 0
02: 1044 4088 00 0
03: 1046 4088 00 0
04: 1048 4088 00 0
05: 104a 4088 00 0
06: 104c 4088 00 0
07: 104e 4088 00 0
08: 1050 4088 00 0
09: 1052 4088 00 0
10: 1054 4088 00 0
11: 1056 4088 00 0
12: 1058 4088 00 0
13: 105a 4088 00 0
14: 105c 4088 00 0
15: 105e 4088 00 0
16: 1060 0000 00 0
17: 1022 4088 00 0
18: 1024 4088 00 0
19: 1026 4088 00 0
20: 1028 4088 00 0
21: 102a 4088 00 0
22: 102c 4088 00 0
23: 102e 4088 00 0
24: 1030 4088 00 0
25: 1032 4088 00 0
26: 1034 4088 00 0
27: 1036 4088 00 0
28: 1038 4088 00 0
29: 103a 4088 00 0
30: 103c 4088 00 0
31: 103e 4088 00 0
Clock: 294
Input: -

```

Pass/Fail: Pass. The emulator performs as expected.

Test 2: Basic Cache Test (Associative)

Setup: The provided “cache_basic.asm” assembly file was assembled using the most recent version of the provided XM-23 assembler. The resulting .xme file was then run using the XM-23 emulator. The emulator cache was set to associative mode.

Expected Results: The cache should be completely filled with addresses from the IR. The usage values should be correctly updated as we are using associative cache organization.

Results: The cache was correctly filled with addresses and instructions from the IR. The usage values are also correctly represented. We can see that the 49th instruction (0000 at address 1060) has been placed in cache line 16. It is the most recently used cache line, represented by its usage value of 31.

```

C:\Users\conno\Desktop\XM-23Emulator\x64\Debug\XM-23 Emulator.exe
Input: 2
IR: 0000 (BL)
Clock: 294
Input: 8
Printing 32 cache lines...
00: 1040 4088 15 0
01: 1042 4088 16 0
02: 1044 4088 17 0
03: 1046 4088 18 0
04: 1048 4088 19 0
05: 104a 4088 20 0
06: 104c 4088 21 0
07: 104e 4088 22 0
08: 1050 4088 23 0
09: 1052 4088 24 0
10: 1054 4088 25 0
11: 1056 4088 26 0
12: 1058 4088 27 0
13: 105a 4088 28 0
14: 105c 4088 29 0
15: 105e 4088 30 0
16: 1060 0000 31 0
17: 1022 4088 00 0
18: 1024 4088 01 0
19: 1026 4088 02 0
20: 1028 4088 03 0
21: 102a 4088 04 0
22: 102c 4088 05 0
23: 102e 4088 06 0
24: 1030 4088 07 0
25: 1032 4088 08 0
26: 1034 4088 09 0
27: 1036 4088 10 0
28: 1038 4088 11 0
29: 103a 4088 12 0
30: 103c 4088 13 0
31: 103e 4088 14 0
Clock: 294
Input: _

```

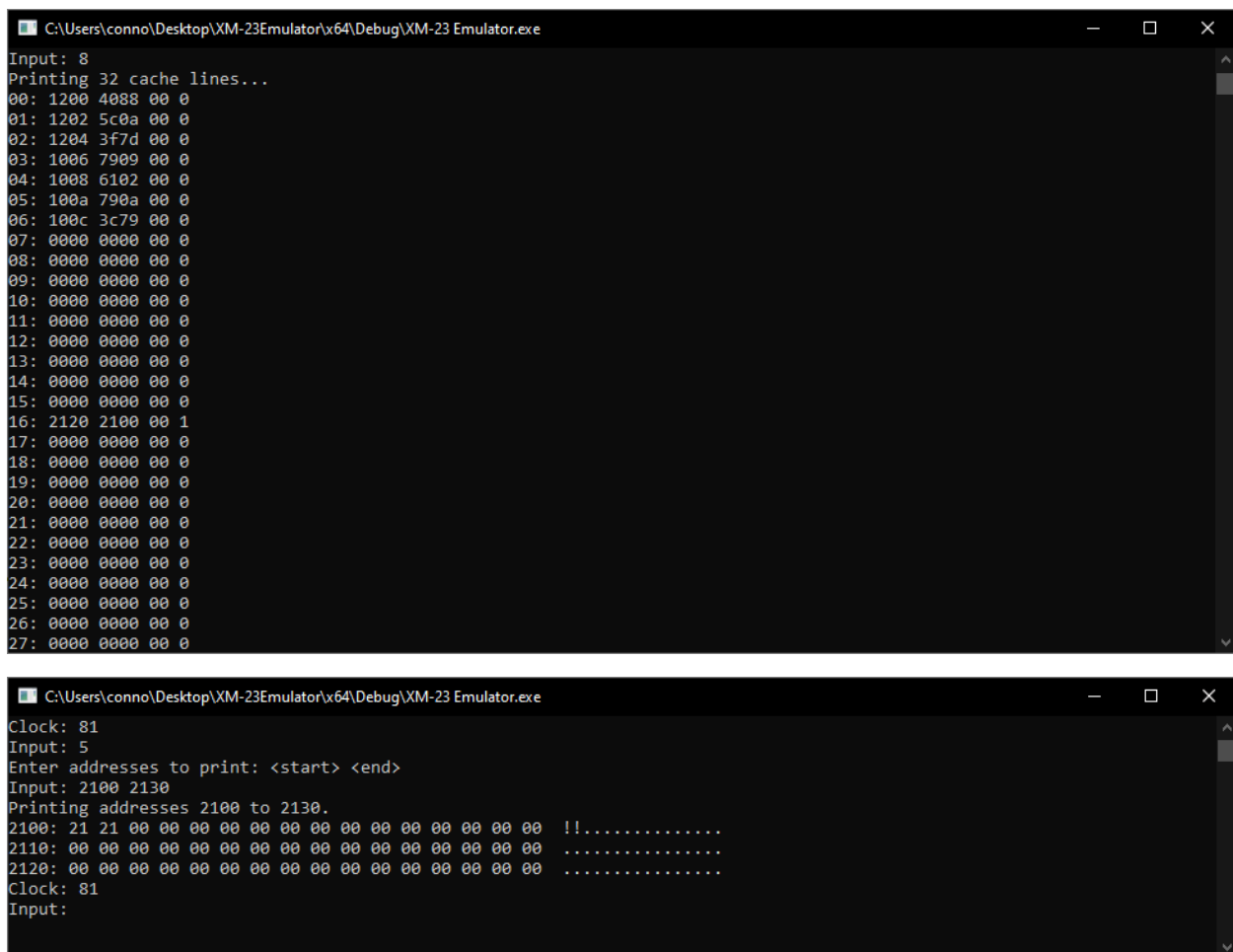
Pass/Fail: Pass. The emulator performs as expected.

Test 3: Writing to Cache (Write-Back)

Setup: The provided “cache_write.asm” assembly file was assembled using the most recent version of the provided XM-23 assembler. The resulting .xme file was then run using the XM-23 emulator. The emulator cache was set to direct mapping mode, using the write-back policy.

Expected Results: The contents of a cache line should only be written to memory after it has been evicted from the cache. The mechanism behind this test can be better understood by looking at the provided test code.

Results: We can see that the write performed at address #2100 has been written to main memory, as it has been evicted from the cache. However, the write performed at address #2120 has not been written to main memory, as it has not been evicted from the cache yet. We can see that the dirty bit is set for this write, indicating that when it is evicted from the cache it will be written to main memory.



The image contains two screenshots of the XM-23 Emulator window. The top screenshot shows the initial state of the 32 cache lines. The bottom screenshot shows the state after a series of operations, including a memory dump of addresses 2100 to 2130.

```

C:\Users\conno\Desktop\XM-23Emulator\x64\Debug\XM-23 Emulator.exe
Input: 8
Printing 32 cache lines...
00: 1200 4088 00 0
01: 1202 5c0a 00 0
02: 1204 3f7d 00 0
03: 1006 7909 00 0
04: 1008 6102 00 0
05: 100a 790a 00 0
06: 100c 3c79 00 0
07: 0000 0000 00 0
08: 0000 0000 00 0
09: 0000 0000 00 0
10: 0000 0000 00 0
11: 0000 0000 00 0
12: 0000 0000 00 0
13: 0000 0000 00 0
14: 0000 0000 00 0
15: 0000 0000 00 0
16: 2120 2100 00 1
17: 0000 0000 00 0
18: 0000 0000 00 0
19: 0000 0000 00 0
20: 0000 0000 00 0
21: 0000 0000 00 0
22: 0000 0000 00 0
23: 0000 0000 00 0
24: 0000 0000 00 0
25: 0000 0000 00 0
26: 0000 0000 00 0
27: 0000 0000 00 0

C:\Users\conno\Desktop\XM-23Emulator\x64\Debug\XM-23 Emulator.exe
Clock: 81
Input: 5
Enter addresses to print: <start> <end>
Input: 2100 2130
Printing addresses 2100 to 2130.
2100: 21 21 00 00 00 00 00 00 00 00 00 00 00 00 00 00 !!.....
2110: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
2120: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
Clock: 81
Input:
  
```

Pass/Fail: Pass. The emulator performs as expected.

Test 4: Writing to Cache (Write-Through)

Setup: The provided “cache_write.asm” assembly file was assembled using the most recent version of the provided XM-23 assembler. The resulting .xme file was then run using the XM-23 emulator. The emulator cache was set to direct mapping mode, using the write-through policy.

Expected Results: The contents of a cache line should be written to memory regardless of whether it has been evicted from the cache.

Results: We can see that both the writes performed at address #2100 and #2120 have been written to main memory. The dirty bit has not been set for the write performed at address #2120, as it is not necessary for the write-through policy.

```

C:\Users\conno\Desktop\XM-23Emulator\x64\Debug\XM-23 Emulator.exe
Printing 32 cache lines...
00: 1200 4088 00 0
01: 1202 5c0a 00 0
02: 1204 3f7d 00 0
03: 1006 7909 00 0
04: 1008 6102 00 0
05: 100a 790a 00 0
06: 100c 3c79 00 0
07: 0000 0000 00 0
08: 0000 0000 00 0
09: 0000 0000 00 0
10: 0000 0000 00 0
11: 0000 0000 00 0
12: 0000 0000 00 0
13: 0000 0000 00 0
14: 0000 0000 00 0
15: 0000 0000 00 0
16: 2120 2100 00 0
17: 0000 0000 00 0
18: 0000 0000 00 0
19: 0000 0000 00 0
20: 0000 0000 00 0
21: 0000 0000 00 0
22: 0000 0000 00 0
23: 0000 0000 00 0
24: 0000 0000 00 0
25: 0000 0000 00 0
26: 0000 0000 00 0
27: 0000 0000 00 0

```

```

C:\Users\conno\Desktop\XM-23Emulator\x64\Debug\XM-23 Emulator.exe
Enter addresses to print: <start> <end>
Input: 2100 2130
Printing addresses 2100 to 2130.
2100: 21 21 00 00 00 00 00 00 00 00 00 00 00 00 00 00 !!.....
2110: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
2120: 22 21 00 00 00 00 00 00 00 00 00 00 00 00 00 00 "!......
Clock: 87
Input:

```

Pass/Fail: Pass. The emulator performs as expected.

Test 5: Instruction Integration

Setup: The provided “cache_inst.asm” assembly file was assembled using the most recent version of the provided XM-23 assembler. The resulting .xme file was then run using the XM-23 emulator. The emulator cache was set to associative mode, using the write-through policy.

Expected Results: We expect to see that instructions that previously used the bus() function are able to be easily adapted to use the cache by replacing the bus() function with the cache_bus() function. These instructions should produce exactly the same results as previous testing indicated, while using the cache.

Results: The instructions provide exactly the same output that was tested previously.

```
C:\Users\conno\Desktop\XM-23Emulator\x64\Debug\XM-23 Emulator.exe
Printing addresses 2100 to 2130.
2100: 21 21 00 00 00 00 00 00 00 00 00 00 00 00 00 00 !!.....
2110: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
2120: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
Clock: 111
Input: _
```

ST instruction.

```
C:\Users\conno\Desktop\XM-23Emulator\x64\Debug\XM-23 Emulator.exe
Printing addresses 2100 to 2130.
2100: 21 21 00 00 00 00 00 00 00 00 00 00 00 00 00 00 !!.....
2110: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
2120: 21 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 !.....
Clock: 120
Input: _
```

ST.B instruction.

```
C:\Users\conno\Desktop\XM-23Emulator\x64\Debug\XM-23 Emulator.exe
Printing register file...
R0: 2121    C0: 0000
R1: 2121    C1: 0001
R2: 2120    C2: 0002
R3: 0000    C3: 0004
R4: 0000 (BP) C4: 0008
R5: 0000 (LR) C5: 0010
R6: 0000 (SP) C6: 0020
R7: 1012 (PC) C7: ffff
Clock: 60
Input: _
```

LD instruction.

```
C:\Users\conno\Desktop\XM-23Emulator\x64\Debug\XM-23 Emulator.exe
Printing register file...
R0: 2121    C0: 0000
R1: 2121    C1: 0001
R2: 0021    C2: 0002
R3: 0000    C3: 0004
R4: 0000 (BP) C4: 0008
R5: 0000 (LR) C5: 0010
R6: 0000 (SP) C6: 0020
R7: 1014 (PC) C7: ffff
Clock: 66
Input: _
```

LD.B instruction.

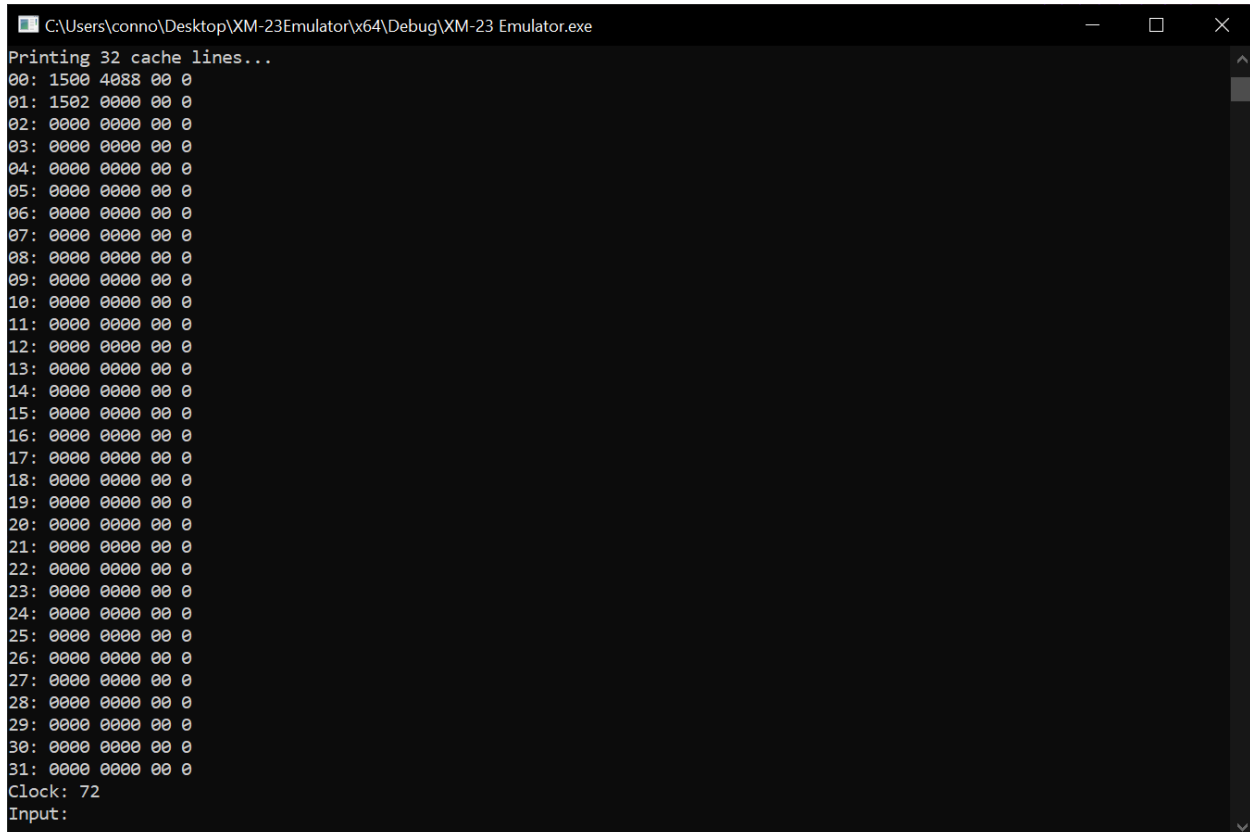
Pass/Fail: Pass. The emulator performs as expected.

Test 6: Defeating Cache (Direct-Mapping)

Setup: The provided “cache_break_dm.asm” assembly file was assembled using the most recent version of the provided XM-23 assembler. The resulting .xme file was then run using the XM-23 emulator. The emulator cache was set to direct-mapping mode, using the write-back policy.

Expected Results: We expect to see very inefficient use of cache space due to the repeated use of similar addresses in the assembly code.

Results: Despite the code containing 11 instructions, only two of the cache lines have been populated.



```

C:\Users\conno\Desktop\XM-23Emulator\x64\Debug\XM-23 Emulator.exe
Printing 32 cache lines...
00: 1500 4088 00 0
01: 1502 0000 00 0
02: 0000 0000 00 0
03: 0000 0000 00 0
04: 0000 0000 00 0
05: 0000 0000 00 0
06: 0000 0000 00 0
07: 0000 0000 00 0
08: 0000 0000 00 0
09: 0000 0000 00 0
10: 0000 0000 00 0
11: 0000 0000 00 0
12: 0000 0000 00 0
13: 0000 0000 00 0
14: 0000 0000 00 0
15: 0000 0000 00 0
16: 0000 0000 00 0
17: 0000 0000 00 0
18: 0000 0000 00 0
19: 0000 0000 00 0
20: 0000 0000 00 0
21: 0000 0000 00 0
22: 0000 0000 00 0
23: 0000 0000 00 0
24: 0000 0000 00 0
25: 0000 0000 00 0
26: 0000 0000 00 0
27: 0000 0000 00 0
28: 0000 0000 00 0
29: 0000 0000 00 0
30: 0000 0000 00 0
31: 0000 0000 00 0
Clock: 72
Input:

```

Pass/Fail: Pass. The emulator performs as expected.


```
C:\Users\conno\Desktop\XM-23Emulator\x64\Debug\XM-23 Emulator.exe
Printing 32 cache lines...
00: 100c 4088 07 0
01: 100e 4088 08 0
02: 1010 4088 09 0
03: 1012 4088 10 0
04: 1014 4088 11 0
05: 1016 4088 12 0
06: 1018 4088 13 0
07: 101a 4088 14 0
08: 101c 4088 15 0
09: 101e 4088 16 0
10: 1020 4088 17 0
11: 1022 4088 18 0
12: 1024 4088 19 0
13: 1026 4088 20 0
14: 1028 4088 21 0
15: 102a 4088 22 0
16: 102c 4088 23 0
17: 102e 4088 24 0
18: 1030 4088 25 0
19: 1032 4088 26 0
20: 1034 4088 27 0
21: 1036 4088 28 0
22: 1038 4088 29 0
23: 103a 4088 30 0
24: 103c 4088 31 0
25: 1040 3fdf 00 0
26: 1000 4088 01 0
27: 1002 4088 02 0
28: 1004 4088 03 0
29: 1006 4088 04 0
30: 1008 4088 05 0
31: 100a 4088 06 0
Clock: 204564
Input: _
```

Pass/Fail: Pass. The emulator performs as expected.