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Experiment 5

AIM: Implement Direct Memory Mapping using Given set of data and link. Use UNC miniMIPS Simulator and C Program.

THEORY:

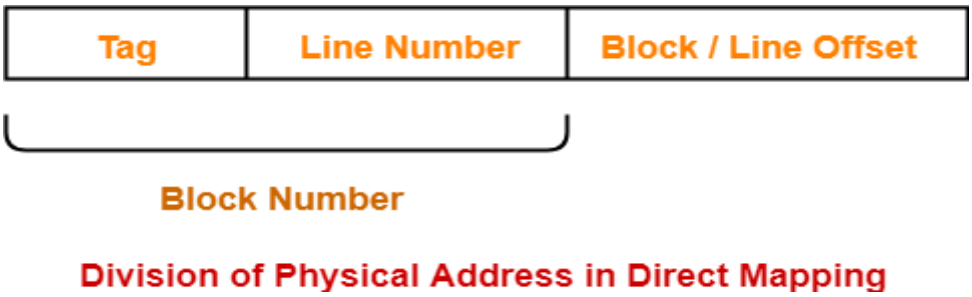
Direct mapping is a procedure used to assign each memory block in the main memory to a particular line in the cache. If a line is already filled with a memory block and a new block needs to be loaded, then the old block is discarded from the cache.

Direct mapping divides an address into three parts:

- t tag bits
- l line bits
- w word bits.

The word bits are the least significant bits that identify the specific word within a block of memory. The line bits are the next least significant bits that identify the line of the cache in which the block is stored. The remaining bits are stored along with the block as the tag which locates the block's position in the main memory.

Cache line number = (Main Memory Block Address) Modulo (Number of lines in Cache)



Division of Physical Address in Direct Mapping

After CPU generates a memory request,

- The line number field of the address is used to access the particular line of the cache.
- The tag field of the CPU address is then compared with the tag of the line.
- If the two tags match, a **cache hit** occurs and the desired word is found in the cache.
- If the two tags do not match, a **cache miss** occurs. In case of a cache miss, the required word has to be brought from the main memory.
- It is then stored in the cache together with the new tag replacing the previous one.

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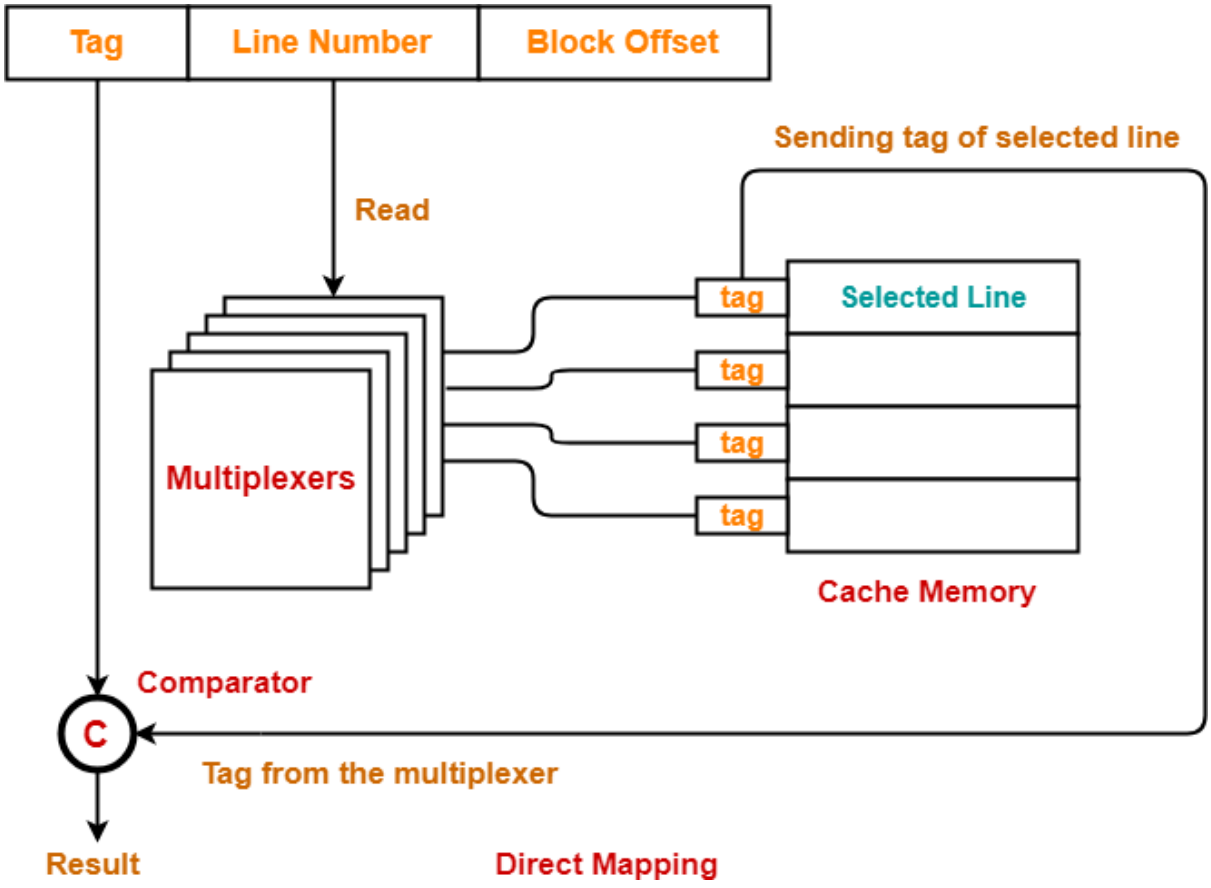

UNC miniMIPS Assembly Language:

A typical line of assembly code specifies a single primitive operation, called an instruction, and its operands. Instructions are specified via short mneumonics of the operation specified. A list of comma-separated operands follows each instruction's mneumonic. The assembler uses this mneumonic and operand list to generate a binary encoding of the instruction, which is stored as a word in memory. Thus, an assembly language program is merely a way of generating a sequence of binary words, that the computer interprets as either (or both) program or data.

Example line of assembly code

add $3, $4, $4 …. ("add" is the instruction mneumonic and "$3,$4,$4" is a list of 3 operands)

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CODE:

Trace file used:

```
main: addu $t0,$0,$0
addiu $t1,$0,80
addu $t2,$0,$0
loop: lw $t3,array($t0)
addu $t2,$t2,$t3
addiu $t0,$t0,4
bne $t0,$t1,loop
*done: beq $0,$0,done
array: .word 1,2,3,4,5,6,7,8,9,10
.word 11,12,13,14,15,16,17,18,19,20
```

trace.txt:

```
0x80000000
0x80000004
0x80000008
0x8000000C
0x00000020
0x80000010
0x80000014
0x80000018
0x8000000C
0x00000024
0x80000010
0x80000014
0x80000018
0x8000000C
0x00000028
0x80000010
0x80000014
0x80000018
0x8000000C
0x0000002C
0x80000010
0x80000014
0x80000018
0x8000000C
0x00000030
```

0x80000010
0x80000014
0x80000018
0x8000000C
0x00000034
0x80000010
0x80000014
0x80000018
0x8000000C
0x00000038
0x80000010
0x80000014
0x80000018
0x8000000C
0x0000003C
0x80000010
0x80000014
0x80000018
0x8000000C
0x00000040
0x80000010
0x80000014
0x80000018
0x8000000C
0x00000044
0x80000010
0x80000014
0x80000018
0x8000000C
0x00000048
0x80000010
0x80000014
0x80000018
0x8000000C
0x0000004C
0x80000010
0x80000014
0x80000018
0x8000000C
0x00000050

0x80000010
0x80000014
0x80000018
0x8000000C
0x00000054
0x80000010
0x80000014
0x80000018
0x8000000C
0x00000058
0x80000010
0x80000014
0x80000018
0x8000000C
0x0000005C
0x80000010
0x80000014
0x80000018
0x8000000C
0x00000060
0x80000010
0x80000014
0x80000018
0x8000000C
0x00000064
0x80000010
0x80000014
0x80000018
0x8000000C
0x00000068
0x80000010
0x80000014
0x80000018
0x8000000C
0x0000006C
0x80000010
0x80000014
0x80000018

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A) Direct Mapping(tag size=8 bits):

```
#include <stdio.h>
int tag[8];
int main( )
{
int addr;
int i, j, t;
int hits, accesses;
FILE *fp;
fp = fopen("trace.txt", "r");
hits = 0;
accesses = 0;
printf("Direct Mapping Program (tag size = 8 bits):\n\n");
while (fscanf(fp, "%x", &addr) > 0) {
/* simulate a direct-mapped cache with 8 words */
accesses += 1;
printf("%3d:0x%08x ", accesses, addr);
printf("\n")
i = (addr >> 2) & 7;
printf(" Cache Location:%d ",i);
t = addr | 0x1f;
printf(" Instruction Address:0x%08x ",t);
printf("tag: 0x%08x ",tag[i]);
if (tag[i] == t) {
hits += 1;
printf(" 'Hit' at %d ", i);
} else {
/* allocate entry */
printf(" 'Miss' ");
tag[i] = t;
}
printf("\n Cache Status:");
for (i = 0; i < 8; i++)
printf("0x%08x ",tag[i]);
printf("\n\n");
}
printf("\n\n");
printf("Hits = %d, Accesses = %d, Hit ratio = %f\n", hits, accesses,
((float)hits)/accesses);
```

```
close(fp);
return 0;
}
```

B) Direct Mapping (tag size=16 bits):

```
#include <stdio.h>
int tag[16];
int main( )
{
int addr;
int i, j, t;
int hits, accesses;
FILE *fp;
fp = fopen("trace.txt", "r");
hits = 0;
accesses = 0;
printf("Direct Mapping Program:\n\n");
while (fscanf(fp, "%x", &addr) > 0) {
/* simulate a direct-mapped cache with 8 words */
accesses += 1;
printf("%4d:0x%08x ", accesses, addr);
printf("\n");
i = (addr >> 2) & 15;
printf(" Cache Location:%d ",i);
t = addr | 0x1f;
printf("\t Instruction Address:0x%08x ",t);
printf("\t tag: 0x%08x ",tag[i]);
if (tag[i] == t) {
hits += 1;
printf("\t 'Hit' at %d ", i);
} else {
/* allocate entry */
printf("\t 'Miss' ");
tag[i] = t;
}
printf("\n Cache Status:");
for (i = 0; i < 16; i++)
printf("0x%08x ",tag[i]);
printf("\n\n");
```

```
}
printf("\n\n");
printf("Hits = %d, Accesses = %d, Hit ratio = %f\n", hits, accesses,
((float)hits)/accesses);
close(fp);
return 0;
}
```

Output:

A) Direct Mapping (tag size = 8 bits):

```
 1:0x80000000
Cache Location:0  Instruction Address:0x8000001f tag: 0x00000000  'Miss'
Cache Status:0x8000001f 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000

 2:0x80000004
Cache Location:1  Instruction Address:0x8000001f tag: 0x00000000  'Miss'
Cache Status:0x8000001f 0x8000001f 0x80000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000

 3:0x80000008
Cache Location:2  Instruction Address:0x8000001f tag: 0x00000000  'Miss'
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000

 4:0x8000000c
Cache Location:3  Instruction Address:0x8000001f tag: 0x00000000  'Miss'
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x00000000 0x00000000 0x00000000

 5:0x00000020
Cache Location:0  Instruction Address:0x0000003f tag: 0x8000001f  'Miss'
Cache Status:0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x00000000 0x00000000 0x00000000

 6:0x80000010
Cache Location:4  Instruction Address:0x8000001f tag: 0x00000000  'Miss'
Cache Status:0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x00000000 0x00000000

 7:0x80000014
Cache Location:5  Instruction Address:0x8000001f tag: 0x00000000  'Miss'
Cache Status:0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x00000000

 8:0x80000018
Cache Location:6  Instruction Address:0x8000001f tag: 0x00000000  'Miss'
Cache Status:0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000

 9:0x8000000c
Cache Location:3  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 3
Cache Status:0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000

10:0x00000024
Cache Location:1  Instruction Address:0x0000003f tag: 0x8000001f  'Miss'
Cache Status:0x0000003f 0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000

11:0x80000010
Cache Location:4  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 4
Cache Status:0x0000003f 0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000

12:0x80000014
Cache Location:5  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 5
Cache Status:0x0000003f 0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000
```

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```
36:0x80000010
Cache Location:4  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 4
Cache Status:0x0000003f 0x0000003f 0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x0000003f 0x00000000

37:0x80000014
Cache Location:5  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 5
Cache Status:0x0000003f 0x0000003f 0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x0000003f 0x00000000

38:0x80000018
Cache Location:6  Instruction Address:0x8000001f tag: 0x0000003f  'Miss'
Cache Status:0x0000003f 0x0000003f 0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000

39:0x8000000c
Cache Location:3  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 3
Cache Status:0x0000003f 0x0000003f 0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000

40:0x0000003c
Cache Location:7  Instruction Address:0x0000003f tag: 0x00000000  'Miss'
Cache Status:0x0000003f 0x0000003f 0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000003f

41:0x80000010
Cache Location:4  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 4
Cache Status:0x0000003f 0x0000003f 0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000003f

42:0x80000014
Cache Location:5  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 5
Cache Status:0x0000003f 0x0000003f 0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000003f

43:0x80000018
Cache Location:6  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 6
Cache Status:0x0000003f 0x0000003f 0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000003f

44:0x8000000c
Cache Location:3  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 3
Cache Status:0x0000003f 0x0000003f 0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000003f

45:0x00000040
Cache Location:0  Instruction Address:0x0000005f tag: 0x0000003f  'Miss'
Cache Status:0x0000005f 0x0000003f 0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000003f

46:0x80000010
Cache Location:4  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 4
Cache Status:0x0000005f 0x0000003f 0x0000003f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000003f
```

```
96:0x80000010
Cache Location:4  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 4
Cache Status:0x0000007f 0x0000007f 0x0000007f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000005f

97:0x80000014
Cache Location:5  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 5
Cache Status:0x0000007f 0x0000007f 0x0000007f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000005f

98:0x80000018
Cache Location:6  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 6
Cache Status:0x0000007f 0x0000007f 0x0000007f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000005f

99:0x8000000c
Cache Location:3  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 3
Cache Status:0x0000007f 0x0000007f 0x0000007f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000005f

100:0x0000006c
Cache Location:3  Instruction Address:0x0000007f tag: 0x8000001f  'Miss'
Cache Status:0x0000007f 0x0000007f 0x0000007f 0x0000007f 0x8000001f 0x8000001f 0x8000001f 0x0000005f

101:0x80000010
Cache Location:4  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 4
Cache Status:0x0000007f 0x0000007f 0x0000007f 0x0000007f 0x8000001f 0x8000001f 0x8000001f 0x0000005f

102:0x80000014
Cache Location:5  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 5
Cache Status:0x0000007f 0x0000007f 0x0000007f 0x0000007f 0x8000001f 0x8000001f 0x8000001f 0x0000005f

103:0x80000018
Cache Location:6  Instruction Address:0x8000001f tag: 0x8000001f  'Hit' at 6
Cache Status:0x0000007f 0x0000007f 0x0000007f 0x0000007f 0x8000001f 0x8000001f 0x8000001f 0x0000005f



Hits = 68, Accesses = 103, Hit ratio = 0.660194

Process returned 0 (0x0)   execution time : 4.334 s
Press any key to continue.
```

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B) Direct Mapping (tag size = 16 bits):

```
Direct Mapping Program(tag size = 16 bits):

  1:0x80000000
Cache Location:0        Instruction Address:0x8000001f          tag: 0x00000000         'Miss'
Cache Status:0x8000001f 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000

  2:0x80000004
Cache Location:1        Instruction Address:0x8000001f          tag: 0x00000000         'Miss'
Cache Status:0x8000001f 0x8000001f 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000

  3:0x80000008
Cache Location:2        Instruction Address:0x8000001f          tag: 0x00000000         'Miss'
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000

  4:0x8000000c
Cache Location:3        Instruction Address:0x8000001f          tag: 0x00000000         'Miss'
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000

  5:0x00000020
Cache Location:8        Instruction Address:0x0000003f          tag: 0x00000000         'Miss'
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x00000000 0x00000000 0x00000000 0x0000003f 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000

  6:0x80000010
Cache Location:4        Instruction Address:0x8000001f          tag: 0x00000000         'Miss'
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x00000000 0x00000000 0x0000003f 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000

  7:0x80000014
Cache Location:5        Instruction Address:0x8000001f          tag: 0x00000000         'Miss'
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x00000000 0x0000003f 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000

  8:0x80000018
Cache Location:6        Instruction Address:0x8000001f          tag: 0x00000000         'Miss'
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000

  9:0x8000000c
Cache Location:3        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 3
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000

 10:0x00000024
Cache Location:9        Instruction Address:0x0000003f          tag: 0x00000000         'Miss'
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x0000003f 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000

 11:0x80000010
Cache Location:4        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 4
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x0000003f 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000

 12:0x80000014
Cache Location:5        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 5
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x0000003f 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000 0x00000000
```

```
 33:0x80000018
Cache Location:6        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 6
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x00000000 0x00000000

 34:0x8000000c
Cache Location:3        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 3
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x00000000 0x00000000

 35:0x00000038
Cache Location:14       Instruction Address:0x0000003f          tag: 0x00000000         'Miss'
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x00000000

 36:0x80000010
Cache Location:4        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 4
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x00000000

 37:0x80000014
Cache Location:5        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 5
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x00000000

 38:0x80000018
Cache Location:6        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 6
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x00000000

 39:0x8000000c
Cache Location:3        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 3
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x00000000

 40:0x0000003c
Cache Location:15       Instruction Address:0x0000003f          tag: 0x00000000         'Miss'
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f

 41:0x80000010
Cache Location:4        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 4
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f

 42:0x80000014
Cache Location:5        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 5
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f

 43:0x80000018
Cache Location:6        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 6
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f

 44:0x8000000c
Cache Location:3        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 3
Cache Status:0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x00000000 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f
```

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```
 95:0x00000068
Cache Location:10       Instruction Address:0x0000007f          tag: 0x0000003f         'Miss'
Cache Status:0x0000005f 0x0000005f 0x0000005f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000005f 0x0000007f 0x0000007f 0x0000007f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f

 96:0x80000010
Cache Location:4        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 4
Cache Status:0x0000005f 0x0000005f 0x0000005f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000005f 0x0000007f 0x0000007f 0x0000007f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f

 97:0x80000014
Cache Location:5        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 5
Cache Status:0x0000005f 0x0000005f 0x0000005f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000005f 0x0000007f 0x0000007f 0x0000007f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f

 98:0x80000018
Cache Location:6        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 6
Cache Status:0x0000005f 0x0000005f 0x0000005f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000005f 0x0000007f 0x0000007f 0x0000007f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f

 99:0x8000000c
Cache Location:3        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 3
Cache Status:0x0000005f 0x0000005f 0x0000005f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000005f 0x0000007f 0x0000007f 0x0000007f 0x0000003f 0x0000003f 0x0000003f 0x0000003f 0x0000003f

100:0x0000006c
Cache Location:11       Instruction Address:0x0000007f          tag: 0x0000003f         'Miss'
Cache Status:0x0000005f 0x0000005f 0x0000005f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000005f 0x0000007f 0x0000007f 0x0000007f 0x0000007f 0x0000003f 0x0000003f 0x0000003f 0x0000003f

101:0x80000010
Cache Location:4        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 4
Cache Status:0x0000005f 0x0000005f 0x0000005f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000005f 0x0000007f 0x0000007f 0x0000007f 0x0000007f 0x0000003f 0x0000003f 0x0000003f 0x0000003f

102:0x80000014
Cache Location:5        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 5
Cache Status:0x0000005f 0x0000005f 0x0000005f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000005f 0x0000007f 0x0000007f 0x0000007f 0x0000007f 0x0000003f 0x0000003f 0x0000003f 0x0000003f

103:0x80000018
Cache Location:6        Instruction Address:0x8000001f          tag: 0x8000001f         'Hit' at 6
Cache Status:0x0000005f 0x0000005f 0x0000005f 0x8000001f 0x8000001f 0x8000001f 0x8000001f 0x0000005f 0x0000007f 0x0000007f 0x0000007f 0x0000007f 0x0000003f 0x0000003f 0x0000003f 0x0000003f


Hits = 72, Accesses = 103, Hit ratio = 0.699029

Process returned 0 (0x0)   execution time : 2.765 s
Press any key to continue.
```

ANALYSIS:

In Direct Mapping, basic requirement is that it Needs only one comparison because of using direct formula to get the effective cache address. Main Memory Address is has 3 fields : TAG, BLOCK & WORD. The BLOCK & WORD together make an index. The least significant TAG bits is used to identify a unique word within a BLOCK of Main Memory. In the cache organization there is aa unique address for each block in the main memory which can be interpreted from the 3 fields. If the processor needs to access same memory location from 2 different main memory pages frequently, cache hit ratio decreases. Search time is less here because there is one possible location in the cache organization for each block from main memory.
Thus, Direct mapping is simple and easy to implement, fast performance, and takes less time to detect a cache hit and get data from the cache.

CONCLUSION:

In this Experiment I implemented Direct Mapping in Cache memory in C programming language using UNC miniMIPS Simulator. First we generated a trace.txt file and observe the number of hits and misses occurred if the tag matches or not with the instruction address. Finally, Hit Ratio is computed, which is greater than 50% for both cases Direct mapping with tag size =8 bits and 16 bits, thus, the number of hits occurred were greater than the number of miss. For 16 bits tag has a larger hit ratio for direct mapping than the 8 bits tag size for the same number of accesses because of the larger cache size.