Homework 5

1. tag = 32-9-6 =17, index = log2512=9, block offset = log264=6

Data bits = 512 bits/block, tag bits = 17, valid bit = 1 so total bits = 512(512+17+1) = 271360

1. tag = 32-6-6 =20, index = log264=6, block offset = log264=6

Data bits = 512 bits/block, tag bits = 20, valid bit = 1 so total bits = 512(512+20+1) = 272896

1. tag = 32-0-6=26, index = log21=0, block offset = log264=6

Data bits = 512 bits/block, tag bits = 26, valid bit = 1 so total bits = 512(512+26+1) = 275968

1. A program exhibits little temporal locality when it does not access the same or similar things at around the same time. A program exhibits little spatial locality when things that it accesses close in time are very far apart in space. An example program pseudocode that wants to sort the data within a file would be:

Fetch last piece of data from the input file

Compare the data collected with the first piece of data that is very far away in memory

Compare the larger of the two with the second to last piece of data

Continue comparing to the second piece of data, third to last piece of data, third piece…

Place largest into new file and remove from input file

Fetch next to last piece of data from the input file

Continue

1. A program exhibits little spatial locality when things it accesses close in time are very far apart in space, but it exhibits high temporal locality when accesses the same or similar code multiple times in a row because it has high likelihood of being used again such as a loop. An example program pseudocode that wants to add data to an array and print them out would be:

Find the memory address of an element and add it to the array

Jump randomly to another memory address that’s 2 GB away and add that into the array

Loop through the array

1. tavg = thit + %miss \* miss penalty
   1. tavg = 1 + 0.05 \*200 = 11ns \* 2 = 22ns
   2. tavg = 2 + 0.1\*(10 + 0.05\*100) = 3.5ns
2. 1. # blocks = 32

# sets = 32

5 = 101, 1 = 1, 8 = 1000, 20 = 10100, 3 = 11, 16 = 10000, 19 = 10011, 56 = 111000, 12 = 1100, 11 = 1011, 4 = 100, 52 = 110100, 5 = 101, 6 = 110, 9 = 1001, 16 = 10000

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Byte-addressed reference | Binary | Tag | Index | Block Offset |
| 5 | 0000 0000 0000 0000 0000 0000 0000 0101 | 0000 0000 0000 0000 0000 0000 0 | 00001 | 01 |
| 1 | 0000 0000 0000 0000 0000 0000 0000 0001 | 0000 0000 0000 0000 0000 0000 0 | 00000 | 01 |
| 8 | 0000 0000 0000 0000 0000 0000 0000 1000 | 0000 0000 0000 0000 0000 0000 0 | 00010 | 00 |
| 20 | 0000 0000 0000 0000 0000 0000 0001 0100 | 0000 0000 0000 0000 0000 0000 0 | 00101 | 00 |
| 3 | 0000 0000 0000 0000 0000 0000 0000 0011 | 0000 0000 0000 0000 0000 0000 0 | 00000 | 11 |
| 16 | 0000 0000 0000 0000 0000 0000 0001 0000 | 0000 0000 0000 0000 0000 0000 0 | 00100 | 00 |
| 19 | 0000 0000 0000 0000 0000 0000 0001 0011 | 0000 0000 0000 0000 0000 0000 0 | 00100 | 11 |
| 56 | 0000 0000 0000 0000 0000 0000 0011 1000 | 0000 0000 0000 0000 0000 0000 0 | 01110 | 00 |
| 12 | 0000 0000 0000 0000 0000 0000 0000 1100 | 0000 0000 0000 0000 0000 0000 0 | 00011 | 00 |
| 11 | 0000 0000 0000 0000 0000 0000 0000 1011 | 0000 0000 0000 0000 0000 0000 0 | 00010 | 11 |
| 4 | 0000 0000 0000 0000 0000 0000 0000 0100 | 0000 0000 0000 0000 0000 0000 0 | 00001 | 00 |
| 52 | 0000 0000 0000 0000 0000 0000 0011 0100 | 0000 0000 0000 0000 0000 0000 0 | 01101 | 00 |
| 5 | 0000 0000 0000 0000 0000 0000 0000 0101 | 0000 0000 0000 0000 0000 0000 0 | 00001 | 01 |
| 6 | 0000 0000 0000 0000 0000 0000 0000 0110 | 0000 0000 0000 0000 0000 0000 0 | 00001 | 10 |
| 9 | 0000 0000 0000 0000 0000 0000 0000 1001 | 0000 0000 0000 0000 0000 0000 0 | 00010 | 01 |
| 16 | 0000 0000 0000 0000 0000 0000 0001 0000 | 0000 0000 0000 0000 0000 0000 0 | 00100 | 00 |

|  |  |  |
| --- | --- | --- |
| Byte-addressed reference | Hit | Miss |
| 5 |  | X |
| 1 |  | X |
| 8 |  | X |
| 20 |  | X |
| 3 | X |  |
| 16 |  | X |
| 19 | X |  |
| 56 |  | X |
| 12 |  | X |
| 11 | X |  |
| 4 | X |  |
| 52 |  | X |
| 5 | X |  |
| 6 | X |  |
| 9 | X |  |
| 16 | X |  |

|  |  |  |
| --- | --- | --- |
| Cache Index | Valid | Final Content Tag |
| 00000 | 1 | 0000 0000 0000 0000 0000 0000 0 |
| 00001 | 1 | 0000 0000 0000 0000 0000 0000 0 |
| 00010 | 1 | 0000 0000 0000 0000 0000 0000 0 |
| 00011 | 1 | 0000 0000 0000 0000 0000 0000 0 |
| 00100 | 1 | 0000 0000 0000 0000 0000 0000 0 |
| 00101 | 1 | 0000 0000 0000 0000 0000 0000 0 |
| 00110 | 0 |  |
| 00111 | 0 |  |
| 01000 | 0 |  |
| 01001 | 0 |  |
| 01010 | 0 |  |
| 01011 | 0 |  |
| 01100 | 0 |  |
| 01101 | 1 | 0000 0000 0000 0000 0000 0000 0 |
| 01110 | 1 | 0000 0000 0000 0000 0000 0000 0 |
| 01111 | 0 |  |
| 10000 | 0 |  |
| 10001 | 0 |  |
| 10010 | 0 |  |
| 10011 | 0 |  |
| 10100 | 0 |  |
| 10101 | 0 |  |
| 10110 | 0 |  |
| 10111 | 0 |  |
| 11000 | 0 |  |
| 11001 | 0 |  |
| 11010 | 0 |  |
| 11011 | 0 |  |
| 11100 | 0 |  |
| 11101 | 0 |  |
| 11110 | 0 |  |
| 11111 | 0 |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Reference | Binary | Tag | Index | Block Offset |
| 172 | 0000 0000 0000 0000 0000 0000 1010 1100 | 0000 0000 0000 0000 0000 0000 1010 | 110 | 0 |
| 44 | 0000 0000 0000 0000 0000 0000 0010 1100 | 0000 0000 0000 0000 0000 0000 0010 | 110 | 0 |
| 4 | 0000 0000 0000 0000 0000 0000 0000 0100 | 0000 0000 0000 0000 0000 0000 0000 | 010 | 0 |
| 172 | 0000 0000 0000 0000 0000 0000 1010 1100 | 0000 0000 0000 0000 0000 0000 1010 | 110 | 0 |
| 104 | 0000 0000 0000 0000 0000 0000 0110 1000 | 0000 0000 0000 0000 0000 0000 0110 | 100 | 0 |
| 32 | 0000 0000 0000 0000 0000 0000 0010 0000 | 0000 0000 0000 0000 0000 0000 0010 | 000 | 0 |
| 192 | 0000 0000 0000 0000 0000 0000 1100 0000 | 0000 0000 0000 0000 0000 0000 1100 | 000 | 0 |
| 88 | 0000 0000 0000 0000 0000 0000 0101 1000 | 0000 0000 0000 0000 0000 0000 0101 | 100 | 0 |
| 200 | 0000 0000 0000 0000 0000 0000 1100 1000 | 0000 0000 0000 0000 0000 0000 1100 | 100 | 0 |
| 16 | 0000 0000 0000 0000 0000 0000 0001 0000 | 0000 0000 0000 0000 0000 0000 0001 | 000 | 0 |
| 56 | 0000 0000 0000 0000 0000 0000 0011 1000 | 0000 0000 0000 0000 0000 0000 0011 | 100 | 0 |
| 184 | 0000 0000 0000 0000 0000 0000 1011 1000 | 0000 0000 0000 0000 0000 0000 1011 | 100 | 0 |
| 52 | 0000 0000 0000 0000 0000 0000 0011 0100 | 0000 0000 0000 0000 0000 0000 0011 | 010 | 0 |
| 196 | 0000 0000 0000 0000 0000 0000 1100 0100 | 0000 0000 0000 0000 0000 0000 1100 | 010 | 0 |
| 254 | 0000 0000 0000 0000 0000 0000 1111 1110 | 0000 0000 0000 0000 0000 0000 1111 | 111 | 0 |

|  |  |  |
| --- | --- | --- |
| Byte Addressed Reference | Hit | Miss |
| 172 |  | X |
| 44 |  | X |
| 4 |  | X |
| 172 | X |  |
| 104 |  | X |
| 32 |  | X |
| 192 |  | X |
| 88 |  | X |
| 200 |  | X |
| 16 |  | X |
| 56 |  | X |
| 184 |  | X |
| 52 |  | X |
| 196 |  | X |
| 254 |  | X |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Cache Index | Block 0 Valid | Final Content Block 0 Tag | Block 1 Valid | Final Content Block 1 Tag |
| 000 | 1 | 0000 0000 0000 0000 0000 0000 0001 | 1 | 0000 0000 0000 0000 0000 0000 1100 |
| 001 | 0 |  | 0 |  |
| 010 | 1 | 0000 0000 0000 0000 0000 0000 1100 | 1 | 0000 0000 0000 0000 0000 0000 0011 |
| 011 | 0 |  | 0 |  |
| 100 | 1 | 0000 0000 0000 0000 0000 0000 1011 | 1 | 0000 0000 0000 0000 0000 0000 0011 |
| 101 | 0 |  | 0 |  |
| 110 | 1 | 0000 0000 0000 0000 0000 0000 1010 | 1 | 0000 0000 0000 0000 0000 0000 0010 |
| 111 | 1 | 0000 0000 0000 0000 0000 0000 1111 |  |  |