

# **Virtual Memory Manager**

Project submitted to the

SRM University – AP, Andhra Pradesh

Submitted in partial fulfilment of the requirement for the award of the degree of

**Bachelor of Technology**

**in**

**Computer Science and Engineering**

**School of Engineering and Sciences**

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# **ACKNOWLEDGEMENT**

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# **AIM OF THE PROJECT**

Designing a Virtual Memory Manager: This project consists of writing a program that translates logical to physical addresses for a virtual address space of size  $2^{16} = 65,536$  bytes. Your program will read from a file containing logical addresses and, using a TLB as well as a page table, will translate each logical address to its corresponding physical address and output the value of the byte stored at the translated physical address. The goal behind this project is to simulate the steps involved in translating logical to physical addresses.

# **DESCRIPTION OF THIS PROJECT**

This project consists of writing a program that translates logical to physical addresses for a virtual address space of size  $2^{16} = 65,536$  bytes. The program will read from a file containing logical addresses and, using a TLB as well as a page table, will translate each logical address to its corresponding physical address and output the value of the byte stored at the translated physical address. The primary purpose of a virtual memory manager is to allow processes to utilize more memory than physically available by leveraging the concept of virtual memory. Virtual memory provides each process with a large and contiguous address space, even if the physical memory is limited.

- The virtual memory manager is simulating the process of logical to physical address translation
- Logical address  $\Rightarrow$  Page Number + Offset
- Physical address  $\Rightarrow$  Frame Number + Offset

# **ROLES AND RESPONSIBILITIES**

<b>Project Member</b>	<b>Contribution</b>
<b>Ashish Chandra Padala</b>	<ul style="list-style-type: none"><li>• Code</li><li>• Project Report</li></ul>
<b>Shiva Kiran Reddy</b>	<ul style="list-style-type: none"><li>• Code</li><li>• Project ppt</li></ul>
<b>Hari Govind MS</b>	<ul style="list-style-type: none"><li>• Code</li><li>• Project ppt</li></ul>

# **SYSTEM REQUIREMENTS**

The system requirements describe the features and behaviour of the system required to run and execute the program.

## **1. SOFTWARE REQUIREMENTS:**

Software requirements is a functional or non-functional need to be implemented in the system.

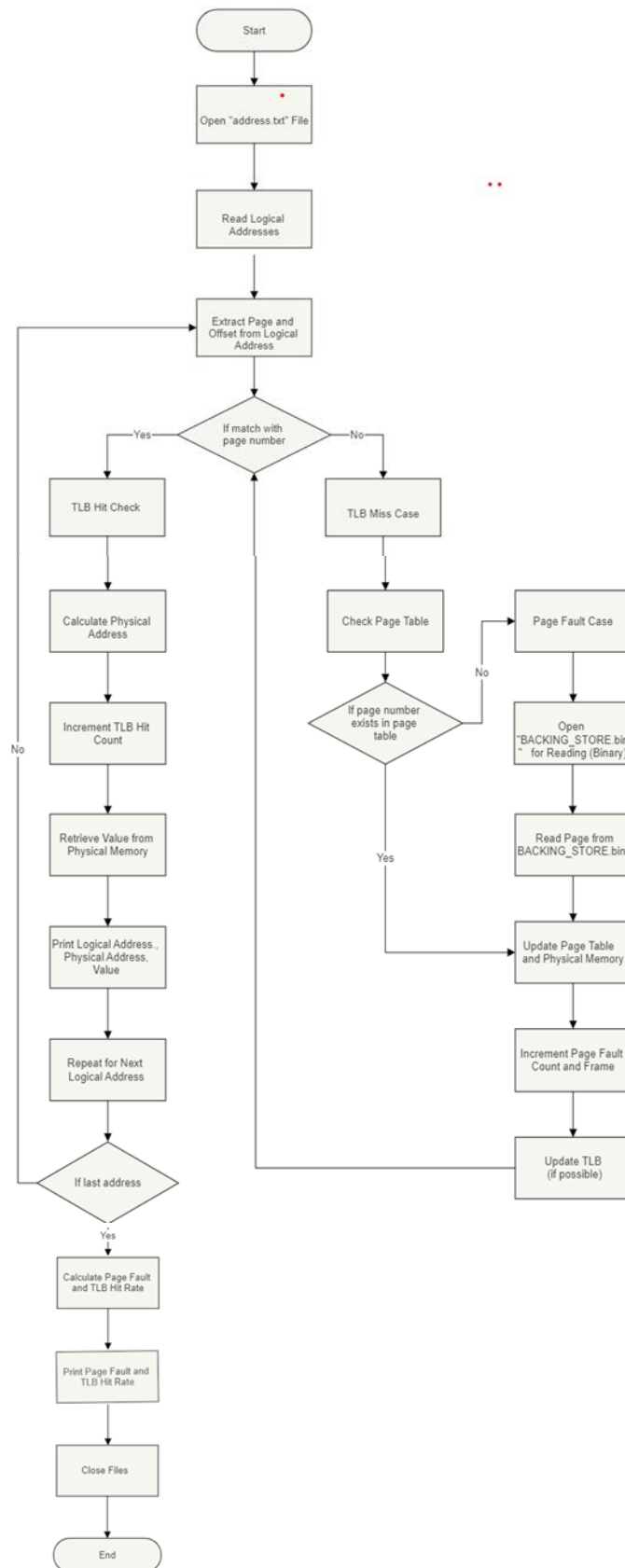
- Language used: Java Language
- IDE: Visual Studio Code and Java IDE

## **2. HARDWARE REQUIREMENTS:**

Hardware requirements are often the versions of the operating system, the memory size needed, and additional peripherals.

- Operating system: Windows
- RAM: 8gb and above
- Processor: Intel i5 or i7, Ryzen 5 and above

# SYSTEM ARCHITECTURE /FLOW CHART



# **ALGORITHM**

1. Initialize necessary variables and data structures.
2. Open "address.txt" for reading. If unsuccessful, display an error message and exit.
3. Read logical addresses from the file.
4. Extract the page number and offset from the logical address.
5. Check the TLB for a match with the page number.
6. If there is a TLB hit, calculate the physical address and increment the TLB hit count.
7. If there is no TLB hit, check the page table for the page number.
8. If the page is not in the page table, it indicates a page fault.
9. Read the corresponding page from "BACKING\_STORE.bin" into the physical memory.
10. Update the page table and TLB with the new page and frame numbers.
11. Calculate the physical address and retrieve the value from physical memory.
12. Print the logical address, physical address, and value.
13. Repeat steps 4-12 for all logical addresses.
14. Calculate the page fault rate and TLB hit rate.



15. Print the page fault rate and TLB hit rate.
16. Close the "address.txt" and "BACKING\_STORE.bin" files.
17. End the program.

# CODE

```
1  #include <stdio.h>
2  #include <stdlib.h>
3  #include <assert.h>
4  #include <unistd.h>
5  #include <string.h>
6
7  const int PAGE_SIZE = 256;
8  const int PAGE_TABLE_SIZE = 256;
9  const int PHYSICAL_MEM_SIZE= 65536;
10 const int TLB_SIZE = 16;
11 /**TLB struct**/
12 /**page & frame**/
13 struct tlb_struct {
14     unsigned int page;
15     unsigned int frame;
16 };
17 int main(int argc, char *argv[]) {
18     int i;
19     /**initialize page_table**/
20     /**256 rows 1 columns**/
21     int page_table[PAGE_TABLE_SIZE];
22     for(i = 0; i < PAGE_TABLE_SIZE; i++) {
23         page_table[i] = -1;
24     }
25     //memset(page_table, -1, PAGE_TABLE_SIZE*sizeof
26     /**initialize page_table**/
27     /**16 rows 2 columns **/
28     struct tlb_struct tlb[TLB_SIZE];
29     for(i = 0; i < TLB_SIZE; i++){
30         tlb[i].page = -1;
31         tlb[i].frame = -1;
32     }
33
34     int physical_memory[PHYSICAL_MEM_SIZE];
35
36     char buffer[PAGE_SIZE];
37
38     int logicalAddress = 0;
39     int page_number = 0;
40     int offset = 0;
41
42     int physical_address=0;
43     int frame = 0;
44     int value = 0;
45
46     int tlb_hit= 0;
47     int tlbIndex = 0;
48     int tlb_buffer = 0;
49
50     int page_fault_count = 0;
51     double page_fault_rate= 0;
52     int tlb_hit_count = 0;
53     double tlb_hit_rate= 0;
54
55     FILE *addressesFile;
56     addressesFile = fopen("address.txt", "r");
57     if (addressesFile == NULL) {
58         printf("address.txt is not available!\n");
59         return 0;
60     }
61
62     /**open backing_store.bin*/
63     FILE *backing_store;
64     backing_store= fopen("BACKING_STORE.bin", "rb");
65     if (backing_store== NULL) {
```

```

66 printf("BACKING STORE.bin is not available!\n");
67 return 0;
68 }
69 /**read the addresses from address.txt**/
70
71 while(fscanf(addressesFile, "%d", &logicalAddress) == 1) {
72     /**mask the right most 16 bits 8 bits pagenumber 8 bits offset**/
73     page_number = (logicalAddress & 0xFF00) >> 8;
74     offset = logicalAddress & 0x00FF;
75     tlb_hit = -1;
76     /**check the TLB to find a match for page number**/
77     for (i = 0; i < tlb_buffer; i++) {
78         if(tlb[i].page == page_number) {
79             tlb_hit = tlb[i].frame;
80             physical_address = tlb_hit*PAGE_SIZE + offset;
81         }
82     }
83     /**if there isn't any match in TLB- it'll check the page table**/
84     if(!(tlb_hit == -1)) {
85         tlb_hit_count++;
86     } else if(page_table [page_number] == -1) {
87         /**it reads from backing store.bin to update the physical memory**/
88         fseek(backing_store, page_number*PAGE_SIZE, SEEK_SET);
89         fread(buffer, sizeof(char), PAGE_SIZE, backing_store);
90         page_table[page_number] = frame;
91         for (i = 0; i < PAGE_SIZE; i++) {
92             physical_memory[frame*PAGE_SIZE + i] = buffer[i];
93         }
94         page_fault_count++;
95         frame++;
96
97         if(tlb_buffer == TLB_SIZE)
98             tlb_buffer--;
99         /** updates the TLB **/
100         for (tlbIndex = tlb_buffer; tlbIndex >0; tlbIndex--) {
101             tlb[tlbIndex].page = tlb[tlbIndex-1].page;
102             tlb[tlbIndex].frame = tlb[tlbIndex-1].frame;
103         }
104
105         if(tlb_buffer <=15)
106             tlb_buffer++;
107         tlb[0].page = page_number;
108         tlb[0].frame = page_table[page_number];
109         physical_address = page_table[page_number]*PAGE_SIZE + offset;}
110     else {
111         physical_address = page_table[page_number]*PAGE_SIZE + offset;
112     }
113     value = physical_memory [physical_address];
114     printf("Logical address: %4d \t", logicalAddress);
115     printf("Physical address: %4d\t", physical_address);
116     printf("Value: %4d\n", value);
117 }
118 page_fault_rate = (double) page_fault_count / 1000 * 100;
119 printf("\nPage Fault Rate: %.2f%% \n", page_fault_rate);
120
121 tlb_hit_rate= ((double) tlb_hit_count / 1000) * 100;
122 printf("TLB HIT Rate:      %.2f \n", tlb_hit_rate);
123
124 fclose(addressesFile);
125 fclose(backing_store);
126
127 return 0;
128 }

```

# CODE EXPLANATION

This code is a simulation of a virtual memory system using a demand-paging scheme. It reads logical addresses from a file, translates them into physical addresses, and retrieves the corresponding values from a simulated physical memory.

Here's a breakdown of the code:

1. The code includes necessary header files and defines constants for page size, page table size, physical memory size, and TLB size.
2. It defines a struct called ``tlb_struct`` to represent entries in the Translation Lookaside Buffer (TLB). Each entry contains a page number and its corresponding frame number.
3. In the ``main`` function, various variables and arrays are initialized, such as ``page_table``, ``tlb``, ``physical_memory``, and ``buffer``.
4. The code opens the ``address.txt`` file and checks if it exists. If the file doesn't exist, an error message is displayed, and the program terminates.
5. It then opens the ``BACKING_STORE.bin`` file, which represents the simulated backing store or disk. Similarly, it checks if the file exists and terminates the program if it doesn't.
6. The code enters a loop to read logical addresses from the ``address.txt`` file. It performs the following steps for each address:
  - A. Extracts the page number and offset from the logical address using bitwise operations.
  - B. Checks if the page number exists in the TLB. If a match is found, it sets ``tlb_hit`` to the corresponding frame number and calculates the physical address using the TLB entry.
  - C. If there is no TLB hit, it checks if the page number exists in the page table. If it doesn't, it indicates a page fault. It reads the corresponding page from the ``BACKING_STORE.bin`` file and updates the page table and physical memory accordingly.

- D. If the TLB is full, it removes the oldest entry by shifting the other entries. It then adds the new TLB entry at the beginning.
  - E. Finally, it calculates the physical address using the page table entry and offset.
7. The code retrieves the value from the physical memory at the calculated physical address and prints the logical address, physical address, and value.
  8. After processing all addresses, it calculates the page fault rate and TLB hit rate based on the respective counters.
  9. The `addressesFile` and `backing\_store` files are closed.
  10. The program terminates and returns 0.

This code essentially simulates the translation of logical addresses to physical addresses using a TLB and a page table. It keeps track of page faults and TLB hits and calculates their respective rates based on the number of address translations performed.

# OUTPUT

Logical address:	41160	Physical address:	712	Value:	0
Logical address:	20595	Physical address:	883	Value:	0
Logical address:	34160	Physical address:	1136	Value:	0
Logical address:	41595	Physical address:	1403	Value:	0
Logical address:	36695	Physical address:	1623	Value:	0
Logical address:	51395	Physical address:	1987	Value:	0
Logical address:	7295	Physical address:	2175	Value:	0
Logical address:	8525	Physical address:	2381	Value:	0
Logical address:	35560	Physical address:	2792	Value:	16
Logical address:	37395	Physical address:	2835	Value:	0
Logical address:	49295	Physical address:	3215	Value:	0
Logical address:	13595	Physical address:	3355	Value:	0
Logical address:	55161	Physical address:	3705	Value:	0
Logical address:	26725	Physical address:	3941	Value:	0
Logical address:	46495	Physical address:	4255	Value:	0
Logical address:	21995	Physical address:	4587	Value:	0
Logical address:	29960	Physical address:	4616	Value:	0
Logical address:	54195	Physical address:	5043	Value:	0
Logical address:	64430	Physical address:	5294	Value:	0
Logical address:	51130	Physical address:	5562	Value:	0
Logical address:	25495	Physical address:	5783	Value:	0
Logical address:	19460	Physical address:	5892	Value:	0
Logical address:	20160	Physical address:	6336	Value:	0
Logical address:	18060	Physical address:	6540	Value:	0
Logical address:	24360	Physical address:	6696	Value:	0
Logical address:	5460	Physical address:	6996	Value:	0
Logical address:	62161	Physical address:	7377	Value:	0
Logical address:	5725	Physical address:	7517	Value:	0
Logical address:	43960	Physical address:	7864	Value:	0
Logical address:	12195	Physical address:	8099	Value:	0
Logical address:	59361	Physical address:	8417	Value:	0
Logical address:	14125	Physical address:	8493	Value:	0
Logical address:	18760	Physical address:	8776	Value:	0
Logical address:	22260	Physical address:	9204	Value:	0
Logical address:	11760	Physical address:	9456	Value:	0
Logical address:	43260	Physical address:	9724	Value:	0
Logical address:	14295	Physical address:	8663	Value:	0
Logical address:	53061	Physical address:	9797	Value:	0
Logical address:	33025	Physical address:	9985	Value:	0
Logical address:	27595	Physical address:	10443	Value:	0
Logical address:	13160	Physical address:	10600	Value:	0

Logical address:	39060	Physical address:	10900	Value:	0
Logical address:	26895	Physical address:	11023	Value:	0
Logical address:	15260	Physical address:	11420	Value:	0
Logical address:	32760	Physical address:	11768	Value:	0
Logical address:	45795	Physical address:	12003	Value:	0
Logical address:	24095	Physical address:	12063	Value:	0
Logical address:	23660	Physical address:	12396	Value:	0
Logical address:	7560	Physical address:	12680	Value:	0
Logical address:	55861	Physical address:	12853	Value:	0
Logical address:	24625	Physical address:	13105	Value:	0
Logical address:	52795	Physical address:	13371	Value:	0
Logical address:	3095	Physical address:	13591	Value:	0
Logical address:	21125	Physical address:	13957	Value:	0
Logical address:	63296	Physical address:	14144	Value:	0
Logical address:	19725	Physical address:	14349	Value:	0
Logical address:	1960	Physical address:	14760	Value:	0
Logical address:	7125	Physical address:	15061	Value:	0
Logical address:	39760	Physical address:	15184	Value:	0
Logical address:	24795	Physical address:	13275	Value:	0
Logical address:	21560	Physical address:	15416	Value:	0
Logical address:	13860	Physical address:	15652	Value:	0
Logical address:	36960	Physical address:	15968	Value:	0
Logical address:	33195	Physical address:	10155	Value:	0
Logical address:	61896	Physical address:	16328	Value:	0
Logical address:	23925	Physical address:	16501	Value:	0
Logical address:	54895	Physical address:	16751	Value:	0
Logical address:	62330	Physical address:	17018	Value:	0
Logical address:	57430	Physical address:	17238	Value:	0
Logical address:	6595	Physical address:	17603	Value:	0
Logical address:	10625	Physical address:	17793	Value:	0
Logical address:	29260	Physical address:	17996	Value:	0
Logical address:	56295	Physical address:	18407	Value:	0
Logical address:	58130	Physical address:	18450	Value:	0
Logical address:	4495	Physical address:	18831	Value:	0
Logical address:	16925	Physical address:	18973	Value:	0
Logical address:	10360	Physical address:	19320	Value:	0
Logical address:	47460	Physical address:	19556	Value:	0
Logical address:	1695	Physical address:	19871	Value:	0
Logical address:	25325	Physical address:	20205	Value:	21
Logical address:	50695	Physical address:	20231	Value:	0
Logical address:	9395	Physical address:	20659	Value:	0

Logical address:	2225	Physical address:	20913	Value:	0
Logical address:	54461	Physical address:	21181	Value:	0
Logical address:	28825	Physical address:	21401	Value:	0
Logical address:	40195	Physical address:	21507	Value:	0
Logical address:	40895	Physical address:	21951	Value:	0
Logical address:	38795	Physical address:	22155	Value:	0
Logical address:	45095	Physical address:	22311	Value:	0
Logical address:	26195	Physical address:	22611	Value:	0
Logical address:	17360	Physical address:	22992	Value:	0
Logical address:	26460	Physical address:	23132	Value:	0
Logical address:	64696	Physical address:	23480	Value:	0
Logical address:	15525	Physical address:	23717	Value:	0
Logical address:	14560	Physical address:	24032	Value:	0
Logical address:	34860	Physical address:	24108	Value:	0
Logical address:	39495	Physical address:	24391	Value:	0
Logical address:	42995	Physical address:	24819	Value:	0
Logical address:	32495	Physical address:	25071	Value:	0
Logical address:	63996	Physical address:	25340	Value:	0
Logical address:	17625	Physical address:	25561	Value:	0
Logical address:	8260	Physical address:	25668	Value:	0
Logical address:	53761	Physical address:	25857	Value:	0
Logical address:	30925	Physical address:	26317	Value:	0
Logical address:	33895	Physical address:	26471	Value:	0
Logical address:	59796	Physical address:	26772	Value:	0
Logical address:	30225	Physical address:	26897	Value:	0
Logical address:	35995	Physical address:	27291	Value:	0
Logical address:	53495	Physical address:	27639	Value:	0
Logical address:	995	Physical address:	27875	Value:	0
Logical address:	27425	Physical address:	10273	Value:	0
Logical address:	44395	Physical address:	28011	Value:	0
Logical address:	28295	Physical address:	28295	Value:	0
Logical address:	11060	Physical address:	28468	Value:	0
Logical address:	45360	Physical address:	28720	Value:	0
Logical address:	7995	Physical address:	28987	Value:	0
Logical address:	6425	Physical address:	17433	Value:	0
Logical address:	41860	Physical address:	29316	Value:	0
Logical address:	18495	Physical address:	29503	Value:	0
Logical address:	40460	Physical address:	29708	Value:	0
Logical address:	22695	Physical address:	30119	Value:	0
Logical address:	27860	Physical address:	30420	Value:	0
Logical address:	60496	Physical address:	30544	Value:	0

Logical address:	28125	Physical address:	30941	Value:	0
Logical address:	42295	Physical address:	31031	Value:	0
Logical address:	34595	Physical address:	31267	Value:	0
Logical address:	57695	Physical address:	31583	Value:	0
Logical address:	53930	Physical address:	26026	Value:	0
Logical address:	17095	Physical address:	19143	Value:	0
Logical address:	44660	Physical address:	31860	Value:	0
Logical address:	10095	Physical address:	32111	Value:	0
Logical address:	125	Physical address:	32381	Value:	0
Logical address:	60761	Physical address:	32601	Value:	0
Logical address:	9925	Physical address:	32965	Value:	0
Logical address:	31360	Physical address:	33152	Value:	0
Logical address:	49995	Physical address:	33355	Value:	0
Logical address:	11495	Physical address:	33767	Value:	0
Logical address:	61461	Physical address:	33813	Value:	0
Logical address:	7825	Physical address:	34193	Value:	0
Logical address:	37660	Physical address:	34332	Value:	0
Logical address:	31095	Physical address:	34679	Value:	0
Logical address:	2660	Physical address:	34916	Value:	0
Logical address:	5025	Physical address:	35233	Value:	0
Logical address:	46060	Physical address:	35564	Value:	-32
Logical address:	5895	Physical address:	35591	Value:	0
Logical address:	12725	Physical address:	36021	Value:	0
Logical address:	22960	Physical address:	36272	Value:	0
Logical address:	9660	Physical address:	36540	Value:	0
Logical address:	49560	Physical address:	36760	Value:	0
Logical address:	60930	Physical address:	36866	Value:	0
Logical address:	61630	Physical address:	33982	Value:	0
Logical address:	59530	Physical address:	37258	Value:	0
Logical address:	295	Physical address:	37415	Value:	0
Logical address:	29525	Physical address:	37717	Value:	0
Logical address:	38095	Physical address:	38095	Value:	0
Logical address:	47195	Physical address:	38235	Value:	0
Logical address:	19895	Physical address:	14519	Value:	0
Logical address:	36260	Physical address:	38564	Value:	0
Logical address:	35295	Physical address:	38879	Value:	0
Logical address:	55595	Physical address:	38955	Value:	0
Logical address:	60230	Physical address:	39238	Value:	0
Logical address:	63730	Physical address:	39666	Value:	0
Logical address:	53230	Physical address:	9966	Value:	64
Logical address:	19195	Physical address:	39931	Value:	0

Logical address:	38360	Physical address:	40152	Value:	0
Logical address:	28995	Physical address:	40259	Value:	0
Logical address:	8960	Physical address:	40448	Value:	0
Logical address:	51660	Physical address:	40908	Value:	0
Logical address:	54630	Physical address:	41062	Value:	0
Logical address:	14995	Physical address:	41363	Value:	0
Logical address:	50960	Physical address:	5392	Value:	0
Logical address:	56730	Physical address:	41626	Value:	0
Logical address:	8695	Physical address:	2551	Value:	0
Logical address:	4325	Physical address:	41957	Value:	1
Logical address:	48160	Physical address:	42016	Value:	0
Logical address:	65131	Physical address:	42347	Value:	0
Logical address:	31625	Physical address:	42633	Value:	0
Logical address:	31795	Physical address:	42803	Value:	0
Logical address:	560	Physical address:	43056	Value:	0
Logical address:	11325	Physical address:	33597	Value:	0
Logical address:	27160	Physical address:	43288	Value:	0
Logical address:	62596	Physical address:	43652	Value:	0
Logical address:	21825	Physical address:	4417	Value:	0
Logical address:	61196	Physical address:	43788	Value:	0
Logical address:	26025	Physical address:	44201	Value:	0
Logical address:	48595	Physical address:	44499	Value:	0
Logical address:	15695	Physical address:	44623	Value:	0
Logical address:	48860	Physical address:	45020	Value:	0
Logical address:	63030	Physical address:	45110	Value:	0
Logical address:	55330	Physical address:	45346	Value:	0
Logical address:	12895	Physical address:	45663	Value:	0
Logical address:	57261	Physical address:	45997	Value:	0
Logical address:	20425	Physical address:	46281	Value:	0
Logical address:	65396	Physical address:	46452	Value:	0
Logical address:	13425	Physical address:	46705	Value:	0
Logical address:	20860	Physical address:	46972	Value:	0
Logical address:	15960	Physical address:	47192	Value:	0
Logical address:	30660	Physical address:	47556	Value:	0
Logical address:	52095	Physical address:	47743	Value:	0
Logical address:	5195	Physical address:	47947	Value:	0
Logical address:	14825	Physical address:	48361	Value:	0
Logical address:	16660	Physical address:	48404	Value:	0
Logical address:	28560	Physical address:	48784	Value:	0
Logical address:	58395	Physical address:	48923	Value:	0
Logical address:	51830	Physical address:	49270	Value:	0

Logical address:	23395	Physical address:	49507	Value:	0
Logical address:	25760	Physical address:	49824	Value:	0
Logical address:	1260	Physical address:	50156	Value:	-32
Logical address:	9225	Physical address:	20489	Value:	0
Logical address:	33460	Physical address:	50356	Value:	0
Logical address:	43695	Physical address:	50607	Value:	0
Logical address:	30395	Physical address:	27067	Value:	0
Logical address:	4760	Physical address:	50840	Value:	0
Logical address:	64261	Physical address:	5125	Value:	0
Logical address:	64961	Physical address:	51137	Value:	0
Logical address:	62861	Physical address:	51341	Value:	0
Logical address:	3625	Physical address:	51497	Value:	0
Logical address:	50260	Physical address:	51796	Value:	0
Logical address:	58830	Physical address:	52174	Value:	0
Logical address:	2395	Physical address:	52315	Value:	0
Logical address:	23225	Physical address:	52665	Value:	0
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Logical address: 59477 Physical address: 37205 Value: 0
Logical address: 62977 Physical address: 45057 Value: 0
Logical address: 52477 Physical address: 56829 Value: 0
Logical address: 18441 Physical address: 29449 Value: 0
Logical address: 55012 Physical address: 16868 Value: 0
Logical address: 28241 Physical address: 28241 Value: 0
```

Page Fault Rate: 25.10%  
TLB HIT Rate: 4.50

# Conclusion

Thus far, this project has assumed that the program will read in the file addresses.txt, which contains 1,000 logical addresses ranging from 0 – 65535. The main context of the program is to translate each logical address to a physical address and determine the contents of the signed byte stored at the correct physical address. In the C language, the char data type occupies a byte of storage, so we suggest using char values. From this process here concluded that the program is to output the following values:

1. The logical address being translated (the integer value being read from addresses.txt).
2. The corresponding physical address (what your program translates the logical address to).
3. The signed byte value is stored at the translated physical address.