Activity 8 - Memory Management

Members

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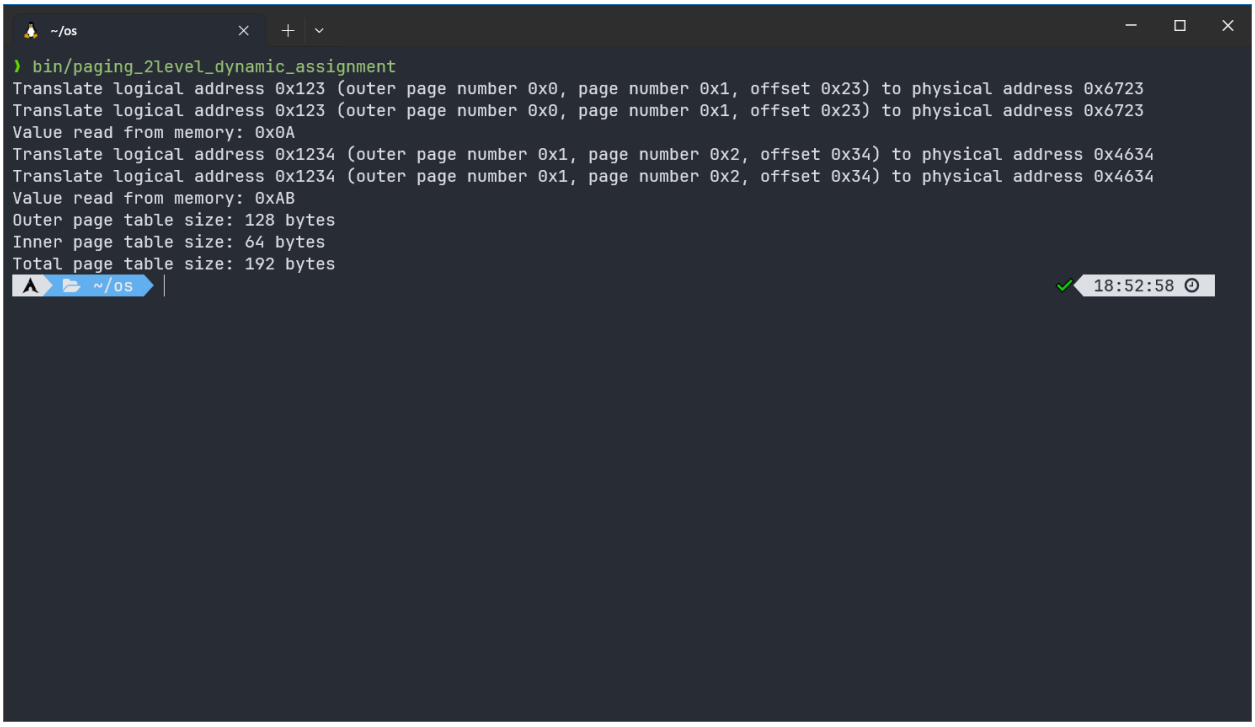
Modified Code

```c
#include <stdio.h>
#include <stdlib.h>
#include <stdint.h>

#define FRAME_SIZE 256
#define FRAME_ENTRIES 128
#define PAGE_SIZE 256
#define PAGE_ENTRIES 16
#define OUTER_PAGE_ENTRIES 16

typedef struct PageTableEntry
{
    uint16_t present : 1;
    uint16_t frame : 15;
} PageTableEntry;

PageTableEntry *page_table;
PageTableEntry *outer_page_table[OUTER_PAGE_ENTRIES];

uint8_t *physical_memory;

uint16_t translate_address(uint16_t logical_address)
{
    // 4 4 8
    // Assignment: complete following statements that get outer page number and page number from logica
    uint8_t outer_page_number = logical_address >> 12;
    uint8_t page_number = (logical_address >> 8) & 0xF;

    // Assignment: complete following statements that allocate inner page table
    if (outer_page_table[outer_page_number] == NULL)
    {
        // Inner page table not present, allocate an inner page table for it
        outer_page_table[outer_page_number] = calloc(PAGE_ENTRIES, sizeof(PageTableEntry));
    }

    if (outer_page_table[outer_page_number][page_number].present == 0)
    {
        // Page not present, allocate a frame for it
        // For simplicity, just random a frame. Must fix this later.
        uint16_t frame_number = rand() % FRAME_ENTRIES;

        // Assignment: complete following statements that fill in page table
        outer_page_table[outer_page_number][page_number].present = 1;
        outer_page_table[outer_page_number][page_number].frame = frame_number;
    }
```

```
    // Assignment: complete following statement that constructs physical address from frame number and
    uint16_t physical_address = (outer_page_table[outer_page_number][page_number].frame << 8)
                              + (logical_address & 0xFF);

    printf("Translate logical address 0x%X (outer page number 0x%X, page number 0x%X, offset 0x%X) to ph
           logical_address, outer_page_number, page_number, logical_address & 0xFF, physical_address);

    return physical_address;
}

void read_from_memory(uint16_t logical_address, uint8_t *value)
{
    uint16_t physical_address = translate_address(logical_address);
    *value = physical_memory[physical_address];
}

void write_to_memory(uint16_t logical_address, uint8_t value)
{
    uint16_t physical_address = translate_address(logical_address);
    physical_memory[physical_address] = value;
}

int main()
{
    // Allocate physical memory
    physical_memory = calloc(PAGE_ENTRIES, PAGE_SIZE);

    // Read and write to memory
    uint8_t value;
    write_to_memory(0x123, 0xA);
    read_from_memory(0x123, &value);
    printf("Value read from memory: 0x%02X\n", value);
    write_to_memory(0x1234, 0xAB);
    read_from_memory(0x1234, &value);
    printf("Value read from memory: 0x%02X\n", value);

    // Calculate total size of outer page table and inner page tables
    size_t page_table_size = 0;
    for (int i = 0; i < OUTER_PAGE_ENTRIES; i++)
    {
        if (outer_page_table[i] != NULL)
        {
            page_table_size += PAGE_ENTRIES * sizeof(PageTableEntry);
        }
    }

    printf("Outer page table size: %zu bytes\n", sizeof(outer_page_table));
    printf("Inner page table size: %zu bytes\n", page_table_size);
    printf("Total page table size: %zu bytes\n", sizeof(outer_page_table) + page_table_size);

    return (0);
}
```

Screenshot


~/os
❯ bin/paging_2level_dynamic_assignment
Translate logical address 0x123 (outer page number 0x0, page number 0x1, offset 0x23) to physical address 0x6723
Translate logical address 0x123 (outer page number 0x0, page number 0x1, offset 0x23) to physical address 0x6723
Value read from memory: 0x0A
Translate logical address 0x1234 (outer page number 0x1, page number 0x2, offset 0x34) to physical address 0x4634
Translate logical address 0x1234 (outer page number 0x1, page number 0x2, offset 0x34) to physical address 0x4634
Value read from memory: 0xAB
Outer page table size: 128 bytes
Inner page table size: 64 bytes
Total page table size: 192 bytes
~/os
18:52:58