ICS 53, Spring 2022 Discussion 4 4/25/2022

Assignment 3

Components

The virtual memory system will have 128 addresses (0 - 127)

The main memory has 32 addresses (0 - 31)

Each page contains 8 addresses

Components

The virtual memory system will have 128 addresses $(0 - 127) \rightarrow \text{virtual memory system}$ will have 16 pages

The main memory has 32 addresses $(0 - 31) \rightarrow$ main memory will have 4 pages

Each page contains 8 addresses

| | | PAGE TAI | BLE | |
|---------|-----|----------|-----|------------------------------|
| | VPN | V | D | PN(MM if V==1, disk if V==0) |
| 0-7 | 0 | 0 | 0 | 0 |
| 8-15 | 1 | 0 | 0 | 1 |
| 16-23 | 2 | 0 | 0 | 2 |
| 24-31 | 3 | 0 | 0 | 3 |
| 32-39 | 4 | 0 | 0 | 4 |
| 40-47 | 5 | 0 | 0 | 5 |
| 48-55 | 6 | 0 | 0 | 6 |
| 56-63 | 7 | 0 | 0 | 7 |
| 64-71 | 8 | 0 | 0 | 8 |
| 72-79 | 9 | 0 | 0 | 9 |
| 80-87 | 10 | 0 | 0 | 10 |
| 88-95 | 11 | 0 | 0 | 11 |
| 96-103 | 12 | 0 | 0 | 12 |
| 104-111 | 13 | 0 | 0 | 13 |
| 112-119 | 14 | 0 | 0 | 14 |
| 119-127 | 15 | 0 | 0 | 15 |
| | | | | |

Main Memory

| 0 | |
|---|--|
| 1 | |
| 2 | |
| 3 | |

| | | PAGE T | ABLE | | | | | |
|---------|-----|--------|------|------------------------------|---|-------------|---|---------------------------|
| | VPN | V | D | PN(MM if V==1, disk if V==0) | | | | > read 9 |
| 0-7 | 0 | 0 | 0 | 0 | | Main Memory | | A Page Fault Has Occurred |
| 8-15 | 1 | 0 | 0 | 1 | | | 7 | -1 |
| 16-23 | 2 | 0 | 0 | 2 | 0 | | | • |
| 24-31 | 3 | 0 | 0 | 3 | | | | |
| 32-39 | 4 | 0 | 0 | 4 | 1 | | | |
| 40-47 | 5 | 0 | 0 | 5 | | | | |
| 48-55 | 6 | 0 | 0 | 6 | _ | | - | |
| 56-63 | 7 | 0 | 0 | 7 | 2 | | | |
| 64-71 | 8 | 0 | 0 | 8 | | | | |
| 72-79 | 9 | 0 | 0 | 9 | 3 | | | |
| 80-87 | 10 | 0 | 0 | 10 | | | | |
| 88-95 | 11 | 0 | 0 | 11 | | | _ | |
| 96-103 | 12 | 0 | 0 | 12 | | | | |
| 104-111 | 13 | 0 | 0 | 13 | | | | |
| 112-119 | 14 | 0 | 0 | 14 | | | | |
| 119-127 | 15 | 0 | 0 | 15 | | | | |
| | | | | | I | | | |

| | | PAGE T | ABLE | | | | |
|---------|-----|--------|------|------------------------------|---|-------------|---------------------------|
| | VPN | V | D | PN(MM if V==1, disk if V==0) | | | > read 9 |
| 0-7 | 0 | 0 | 0 | 0 | | Main Memory | A Page Fault Has Occurred |
| 8-15 | 1 | 1 | 0 | 0 | | | -1 |
| 16-23 | 2 | 0 | 0 | 2 | 0 | | |
| 24-31 | 3 | 0 | 0 | 3 | 1 | | > write 9 201 |
| 32-39 | 4 | 0 | 0 | 4 | 1 | | |
| 40-47 | 5 | 0 | 0 | 5 | | | |
| 48-55 | 6 | 0 | 0 | 6 | | | |
| 56-63 | 7 | 0 | 0 | 7 | 2 | | |
| 64-71 | 8 | 0 | 0 | 8 | | | |
| 72-79 | 9 | 0 | 0 | 9 | 3 | | |
| 80-87 | 10 | 0 | 0 | 10 | | | |
| 88-95 | 11 | 0 | 0 | 11 | | | |
| 96-103 | 12 | 0 | 0 | 12 | | | |
| 104-111 | 13 | 0 | 0 | 13 | | | |
| 112-119 | 14 | 0 | 0 | 14 | | | |
| 119-127 | 15 | 0 | 0 | 15 | | | |
| | | | | | ı | | |

| | | PAGE T | ABLE | | | Main Memory | |
|---------|-----|--------|------|------------------------------|---|----------------|---------------------------|
| | VPN | V | D | PN(MM if V==1, disk if V==0) | 0 | 0 8: | > read 9 |
| 0-7 | 0 | 0 | 0 | 0 | 1 | 1 9: 201 | A Page Fault Has Occurred |
| 8-15 | 1 | 1 | 1 | 0 | • | 2 10: | -1 |
| 16-23 | 2 | 0 | 0 | 2 | | 3 11: | |
| 24-31 | 3 | 0 | 0 | 3 | | 4 12: 5 13: | > write 9 201 |
| 32-39 | 4 | 0 | 0 | 4 | | 6 14: | > read 9 |
| 40-47 | 5 | 0 | 0 | 5 | | 7 15: | 201 |
| 48-55 | 6 | 0 | 0 | 6 | 1 | | |
| 56-63 | 7 | 0 | 0 | 7 | 1 | | > showmain 0 |
| 64-71 | 8 | 0 | 0 | 8 | | | 0: -1 |
| 72-79 | 9 | 0 | 0 | 9 | 2 | | 1: 201 2: -1 |
| 80-87 | 10 | 0 | 0 | 10 | | | 3: -1 |
| 88-95 | 11 | 0 | 0 | 11 | 3 | | 5: -1 |
| 96-103 | 12 | 0 | 0 | 12 | | | 6: -1 7: -1 |
| 104-111 | 13 | 0 | 0 | 13 | | | |
| 112-119 | 14 | 0 | 0 | 14 | | | > showptable |
| 119-127 | 15 | 0 | 0 | 15 | | | |
| | | | | | | | |

| | | PAGE | TABLE | | | | | Main Memory | |
|---------|-----|------|-------|------|---------------------------|---|---|----------------|---|
| | VPN | V | D | PN(N | 1M if V==1, disk if V==0) | |) | 0 8: | |
| 0-7 | 0 | 0 | 0 | 0 | | | 1 | 1 9: 201 | |
| 8-15 | 1 | 1 | 1 | 0 | | | • | 2 10: | |
| 16-23 | 2 | 0 | 0 | 2 | | | | 3 11: | |
| 24-31 | 3 | 0 | 0 | 3 | | | | 4 12: 5 13: | |
| 32-39 | 4 | 0 | 0 | 4 | | | | 6 14: | |
| 40-47 | 5 | 0 | 0 | 5 | | | | 7 15 : | |
| 48-55 | 6 | 0 | 0 | 6 | | | 1 | | - |
| 56-63 | 7 | 0 | 0 | 7 | | | • | | |
| 64-71 | 8 | 0 | 0 | 8 | | | | | _ |
| 72-79 | 9 | 0 | 0 | 9 | | 2 | 2 | | |
| 80-87 | 10 | 0 | 0 | 10 | | | | | |
| 88-95 | 11 | 0 | 0 | 11 | | 3 | 3 | | |
| 96-103 | 12 | 0 | 0 | 12 | | | | | |
| 104-111 | 13 | 0 | 0 | 13 | | | | | _ |
| 112-119 | 14 | 0 | 0 | 14 | | | | | |
| 119-127 | 15 | 0 | 0 | 15 | | | | | |

| 1 | 0 8: 1 9: 201 2 10: 3 11: 4 12: 5 13: 6 14: 7 15: | |
|---|--|--|
| 1 | | |
| 2 | | |
| 3 | | |

> read 9

> write 9 201

> showmain 0

> showptable

> read 9

201

0: -1 1: 201 2: -1 3: -1 5: -1 6: -1 7: -1

-1

A Page Fault Has Occurred

| | | PAGE T | ABLE | | | | Main Memory |
|---------|-----|--------|------|------------------------------|---|---|-------------|
| | VPN | V | D | PN(MM if V==1, disk if V==0) | | 0 | 0 |
| 0-7 | 0 | 0 | 0 | 0 | | | 1 |
| 8-15 | 1 | 0 | 0 | 0 | | | 2 |
| 16-23 | 2 | 0 | 0 | 2 | | | 3 |
| 24-31 | 3 | 0 | 0 | 3 | | | 4 5 |
| 32-39 | 4 | 0 | 0 | 4 | | | 6 |
| 40-47 | 5 | 0 | 0 | 5 | | | 7 |
| 48-55 | 6 | 0 | 0 | 6 | | 1 | |
| 56-63 | 7 | 0 | 0 | 7 | | 1 | |
| 64-71 | 8 | 0 | 0 | 8 | | | |
| 72-79 | 9 | 0 | 0 | 9 | | 2 | |
| 80-87 | 10 | 0 | 0 | 10 | | | |
| 88-95 | 11 | 0 | 0 | 11 | | 3 | |
| 96-103 | 12 | 0 | 0 | 12 | | | |
| 104-111 | 13 | 0 | 0 | 13 | | | |
| 112-119 | 14 | 0 | 0 | 14 | | | |
| 119-127 | 15 | 0 | 0 | 15 | | | |
| | | | | | I | | |

> write 10 202

A Page Fault Has Occurred

| | | PAGE TAI | BLE | | | Main Memory |
|---------|-----|----------|-----|------------------------------|---|-------------------|
| | VPN | V | D | PN(MM if V==1, disk if V==0) | 0 | 0 8: |
| 0-7 | 0 | 0 | 0 | 0 | 1 | 1 9: |
| 8-15 | 1 | 1 | 1 | 0 | ' | 2 10 : 202 |
| 16-23 | 2 | 0 | 0 | 2 | | 3 11: |
| 24-31 | 3 | 0 | 0 | 3 | | 4 12: 5 13: |
| 32-39 | 4 | 0 | 0 | 4 | | 6 14: |
| 40-47 | 5 | 0 | 0 | 5 | | 7 15: |
| 48-55 | 6 | 0 | 0 | 6 | 1 | |
| 56-63 | 7 | 0 | 0 | 7 | 1 | |
| 64-71 | 8 | 0 | 0 | 8 | | |
| 72-79 | 9 | 0 | 0 | 9 | 2 | |
| 80-87 | 10 | 0 | 0 | 10 | | |
| 88-95 | 11 | 0 | 0 | 11 | 3 | |
| 96-103 | 12 | 0 | 0 | 12 | | |
| 104-111 | 13 | 0 | 0 | 13 | | |
| 112-119 | 14 | 0 | 0 | 14 | | |
| 119-127 | 15 | 0 | 0 | 15 | | |

> write 10 202

A Page Fault Has Occurred

| | | PAGE 1 | TABLE | | | Main Memory | | | | |
|---------|-----|--------|-------|------------------------------|---|--------------------|---------------------------|--|--|--|
| | VPN | V | D | PN(MM if V==1, disk if V==0) | 0 | 0 8: | > write 10 202 | | | |
| 0-7 | 0 | 1 | 0 | 3 | 1 | 1 9: | A Page Fault Has Occurred | | | |
| 8-15 | 1 | 1 | 1 | 0 | | 2 10 : 202 | > write 31 403 | | | |
| 16-23 | 2 | 0 | 0 | 2 | | 3 11: | witte of 400 | | | |
| 24-31 | 3 | 1 | 1 | 1 | | 4 12: | A Page Fault Has Occurred | | | |
| 32-39 | 4 | 0 | 0 | 4 | | 5 13: 6 14: | > read 72 | | | |
| 40-47 | 5 | 0 | 0 | 5 | | 7 15: | A Page Fault Has Occurred | | | |
| 48-55 | 6 | 0 | 0 | 6 | 1 | | | | | |
| 56-63 | 7 | 0 | 0 | 7 | 3 | 15 31 : 403 | -1 | | | |
| 64-71 | 8 | 0 | 0 | 8 | | | > read 0 | | | |
| 72-79 | 9 | 1 | 0 | 2 | 2 | | A Page Fault Has Occurred | | | |
| 80-87 | 10 | 0 | 0 | 10 | 9 | | -1 | | | |
| 88-95 | 11 | 0 | 0 | 11 | 3 | | -1 | | | |
| 96-103 | 12 | 0 | 0 | 12 | 0 | | | | | |
| 104-111 | 13 | 0 | 0 | 13 | | | | | | |
| 112-119 | 14 | 0 | 0 | 14 | | | | | | |
| 119-127 | 15 | 0 | 0 | 15 | | | | | | |
| | | | | I | | | | | | |

| | PAGE TABLE | | | | | | | |
|---------|------------|---|---|-------------------|--------------|---|--------------------|---------------|
| | VPN | V | D | PN(MM if V==1, di | isk if V==0) | 0 | 0 8: | > read 12 |
| 0-7 | 0 | 1 | 0 | 3 | | 1 | 1 9: 300 | -1 |
| 8-15 | 1 | 1 | 1 | 0 | | | 2 10 : 202 | > write 9 300 |
| 16-23 | 2 | 0 | 0 | 2 | | | 3 11: | |
| 24-31 | 3 | 1 | 1 | 1 | | | 4 12: 5 13: | > showmain 1 |
| 32-39 | 4 | 0 | 0 | 4 | | | 6 14: | 8:-1 |
| 40-47 | 5 | 0 | 0 | 5 | | | 7 15: | 9:-1 |
| 48-55 | 6 | 0 | 0 | 6 | | 1 | | |
| 56-63 | 7 | 0 | 0 | 7 | | 3 | 15 31 : 403 | 10:-1 |
| 64-71 | 8 | 0 | 0 | 8 | | | | 11:-1 |
| 72-79 | 9 | 1 | 0 | 2 | | 2 | | 12:-1 |
| 80-87 | 10 | 0 | 0 | 10 | | 9 | | 13:-1 |
| 88-95 | 11 | 0 | 0 | 11 | | 3 | | |
| 96-103 | 12 | 0 | 0 | 12 | | 0 | | 14:-1 |
| 104-111 | 13 | 0 | 0 | 13 | | | | 15:403 |
| 112-119 | 14 | 0 | 0 | 14 | | | | > showptable |
| 119-127 | 15 | 0 | 0 | 15 | | | | |

| | | PAGE T | ABLE | | | | Main Memory |
|---------|----------|----------|----------|------------------------------|---|----------|--------------------|
| | VPN | V | D | PN(MM if V==1, disk if V==0) | | 0 | 0 8: |
| 0-7 | 0 | 1 | 0 | 3 | | 1 | 1 9: 300 |
| 8-15 | 1 | 1 | 1 | 0 | | • | 2 10: 202 |
| 16-23 | 2 | 0 | 0 | 2 | | | 3 11: |
| 24-31 | 3 | 1 | 1 | 1 | | | 4 12: 5 13: |
| 32-39 | <u>4</u> | <u>0</u> | <u>0</u> | <u>4</u> | | | 6 14: |
| 40-47 | 5 | 0 | 0 | 5 | | | 7 15 : |
| 48-55 | 6 | 0 | 0 | 6 | | 1 | |
| 56-63 | 7 | 0 | 0 | 7 | | 3 | 15 31 : 403 |
| 64-71 | 8 | 0 | 0 | 8 | | <u> </u> | 10011100 |
| 72-79 | 9 | 1 | 0 | 2 | | 2 | |
| 80-87 | 10 | 0 | 0 | 10 | | 9 | |
| 88-95 | 11 | 0 | 0 | 11 | | 3 | |
| 96-103 | 12 | 0 | 0 | 12 | | 0 | |
| 104-111 | 13 | 0 | 0 | 13 | | | |
| 112-119 | 14 | 0 | 0 | 14 | | | |
| 119-127 | 15 | 0 | 0 | 15 | | | |
| | | | | | I | | |

> write 32 40

A Page Fault Has Occurred

-1

| VPN V D PN(MM if V==1, disk if V==0) | | PAGE TABLE | | | | Main Memory | | |
|--|---------|------------|---|---|------------------------------|-----------------------|----------|---------------------------|
| 0.7 | | VPN | V | D | PN(MM if V==1, disk if V==0) | 0 | 0.8. | > write 32 40 |
| 8-15 | 0-7 | 0 | 1 | 0 | 3 | | | A Page Fault Has Occurred |
| 16-23 | 8-15 | 1 | 1 | 1 | 0 | ' | | |
| 24-31 3 0 0 3 3 8:40 32-39 4 1 1 1 1 40-47 5 0 0 0 5 48-55 6 0 0 0 6 56-63 7 0 0 0 7 64-71 8 0 0 0 8 72-79 9 1 0 2 80-87 10 0 0 0 10 88-95 11 0 0 0 11 98-103 12 0 0 12 104-111 13 0 0 13 112-119 14 0 0 14 119-127 15 0 0 0 15 Address access order: 10(1), 31(3), 72(9), 0(0), 12(1), 9(1) | 16-23 | 2 | 0 | 0 | 2 | | 3 11: | -1 |
| 32-39 4 1 1 1 1 40-47 5 0 0 5 14: 7 15: 9:-1 9:-1 9:-1 10:-1 10:-1 10:-1 10:-1 11:-1 11:-1 11:-1 11:-1 11:-1 11:-1 11:-1 11:-1 13:-1 13:-1 13:-1 14:-1 13:-1 14:-1 15:-1 15:-1 > showptable < | 24-31 | 3 | 0 | 0 | 3 | | | > showmain 1 |
| 40-47 | | | | | | | | 0.40 |
| 48-55 | 32-39 | 4 | 1 | 1 | 1 | | | 8:40 |
| 56-63 7 0 0 7 64-71 8 0 0 8 72-79 9 1 0 2 80-87 10 0 0 10 88-95 11 0 0 11 96-103 12 0 0 12 104-111 13 0 0 13 112-119 14 0 0 14 119-127 15 0 0 15 Address access order: 10(1), 31(3), 72(9), 0(0), 12(1), 9(1) > showptable | 40-47 | 5 | 0 | 0 | 5 | | 7 15: | 9:-1 |
| 56-63 | 48-55 | 6 | 0 | 0 | 6 | 1 | 8 32: 40 | 40.4 |
| 64-71 8 0 0 8 | 56-63 | 7 | 0 | 0 | 7 | | 0 32. 40 | 10:-1 |
| 80-87 | 64-71 | 8 | 0 | 0 | 8 | | | 11:-1 |
| 80-87 | 72-79 | 9 | 1 | 0 | 2 | 2 | | 12:-1 |
| 88-95 11 0 0 0 11 3 0 0 12 14:-1 15:-1 15 0 0 15 15 15 0 0 15 15 | 80-87 | 10 | 0 | 0 | 10 | 9 | | 12 |
| 96-103 12 0 0 12 | | | | | | | | 13:-1 |
| 90-103 12 | | | | | | 3 | | 14:-1 |
| Address access order: 112-119 | 96-103 | 12 | 0 | 0 | 12 | 0 | | 141 |
| 119-127 15 0 0 15 Tada 855 disease state: > showptable 10(1), 31(3), 72(9), 0(0), 12(1), 9(1) | 104-111 | 13 | 0 | 0 | 13 | | | 15:-1 |
| 119-127 15 0 0 15 10(1), 31(3), 72(9), 0(0), 12(1), 9(1) | 112-119 | 14 | 0 | 0 | 14 | Address access order: | | > showptable |
| | 119-127 | 15 | 0 | 0 | 15 | | | |

Data Structure

```
struct Memory {
  int address, data;
};
struct PageTable {
  int v_page_num, valid_bit, dirty_bit, page_num, time_stamp;
};
struct Memory main_memory[32];
struct Memory virtual memory[128];
struct PageTable p table[8];
```

Initialization

```
int i;
  for (i = 0; i < sizeof(main_memory)/sizeof(main_memory[0]); i++) {
     main_memory[i].data = -1;
     main_memory[i].address = i;
   for (i = 0; i < sizeof(virtual_memory)/sizeof(virtual_memory[0]); i++) {
     virtual_memory[i].data = -1;
     virtual_memory[i].address = i;
   for (i = 0; i < sizeof(p_table)/sizeof(p_table[0]); i++) {
     p_table[i].v_page_num = p_table[i].page_num = i;
     p_table[i].valid_bit = p_table[i].dirty_bit = 0;
     p_table[i].time_stamp = 0;
```

Main

```
char* input[100];
int fifo = 0, Iru = 0;
                                                                       char** args;
int main(int argc, char** argv) {
                                                                       do {
  if (argv[1] == NULL || strcmp (argv[1], "FIFO") == 0)
                                                                         printf("> ");
     fifo = 1;
                                                                         fgets(input, 80, stdin);
  else if (strcmp (argv[1], "LRU") == 0)
                                                                         args = tokenize((char *) input);
     Iru = 1;
                                                                         if (strcmp(args[0], "quit") == 0)
  init();
                                                                            exit(0);
  loop();
                                                                         execute(args);
  return 0;
                                                                       } while (1);
```

void loop() {

Think about

Virtual to physical address conversion formula

Thank you!!

Questions?