Page Table II

CS 241

Sept. 16, 2013

Page Size: 4 KB

Physical RAM
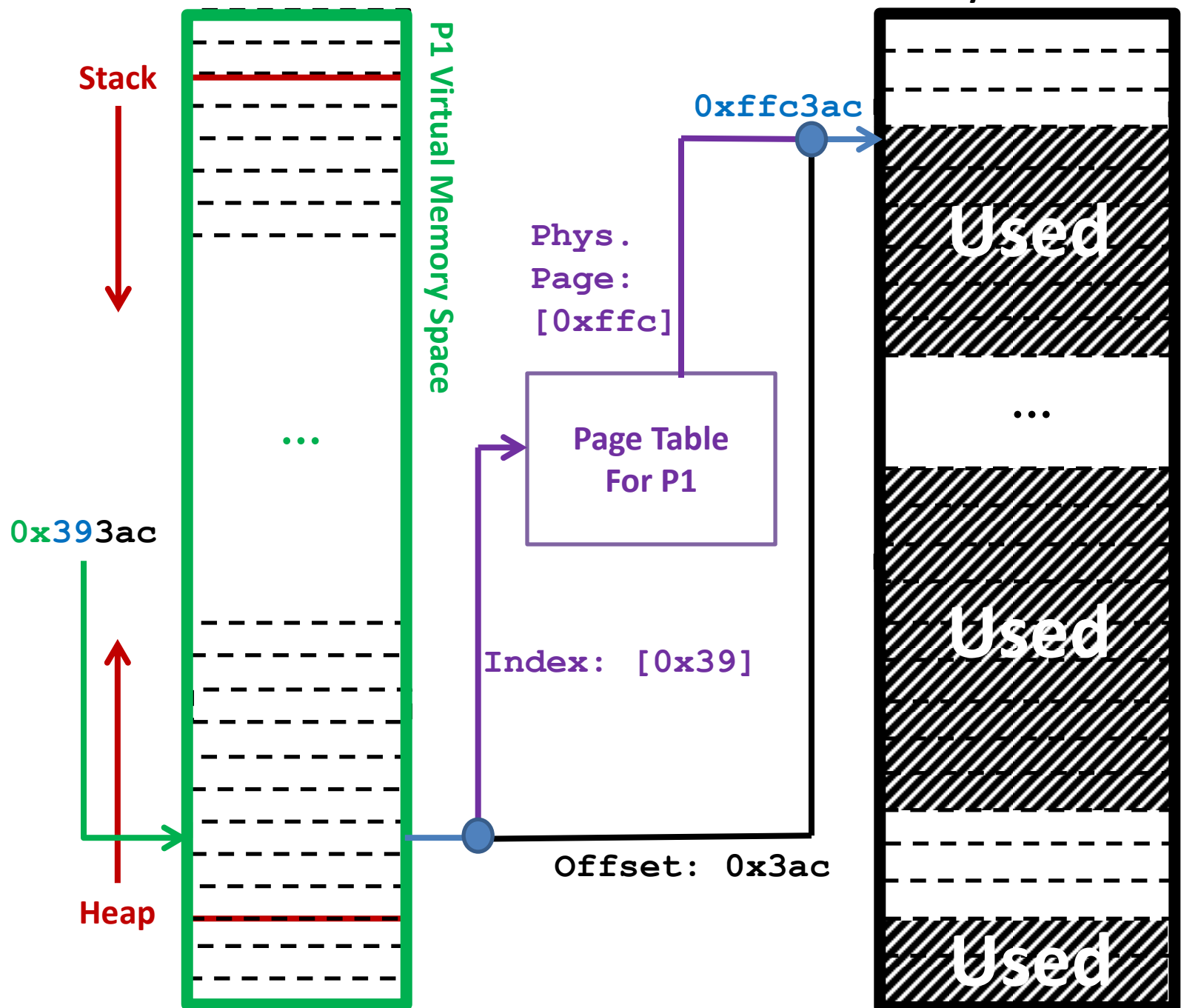
Stack

P1 Virtual Memory Space

`0xffc3ac`

Phys.
Page:
[0xffc]

Used

`0x39`3ac

...

...

Page Table
For P1

Index: [0x39]

Used

Offset: 0x3ac

Heap

Used

Page Eviction

Virtual Page #: 17

Virtual Page #: 33

Virtual Page #: 40

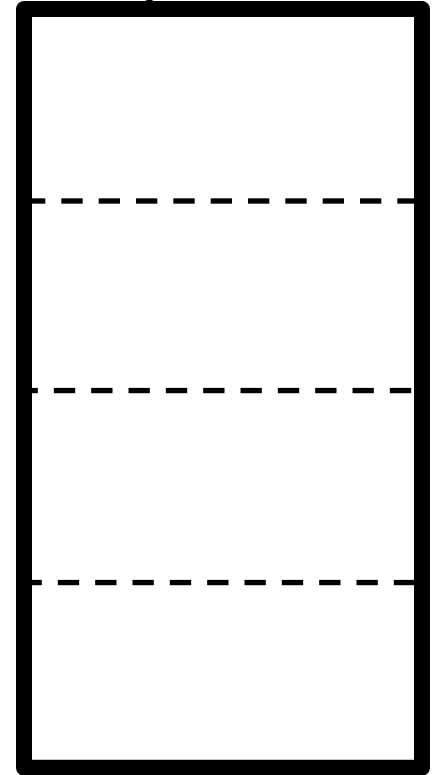Virtual Page #: 17

Virtual Page #: 43

Virtual Page #: 8

Virtual Page #: 99

Virtual Page #: 33

Virtual Page #: 99

Virtual Page #: 17

Physical RAM

Page Eviction Strategies

- Optimal (**OPT**)

- Least Recently Used (**LRU**)

- Least Frequently used (**LFU**)

- Not Recently Used (**NRU**) / Access Bit

- Working Set

Page Eviction

Virtual Page #: 17 →

Virtual Page #: 33 →

Virtual Page #: 40 →

Virtual Page #: 17 →

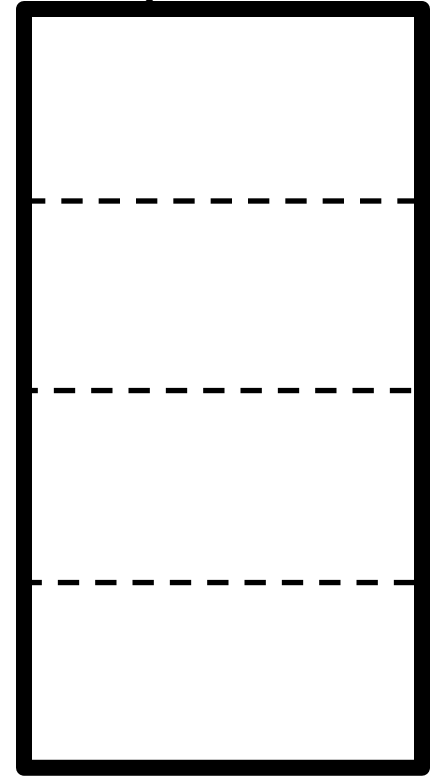Virtual Page #: 43 →

Virtual Page #: 8 →

Virtual Page #: 99 →

Virtual Page #: 33 →

Virtual Page #: 99 →

Virtual Page #: 17 →

Physical RAM

Page Eviction

Virtual Page #: 17 →

Virtual Page #: 33 →

Virtual Page #: 40 →

Virtual Page #: 17 →

Virtual Page #: 43 →

Virtual Page #: 8 →

Virtual Page #: 99 →

Virtual Page #: 33 →

Virtual Page #: 99 →

Virtual Page #: 17 →

Physical RAM

Page Eviction

Virtual Page #: 17 →

Virtual Page #: 33 →

Virtual Page #: 40 →

Virtual Page #: 17 →
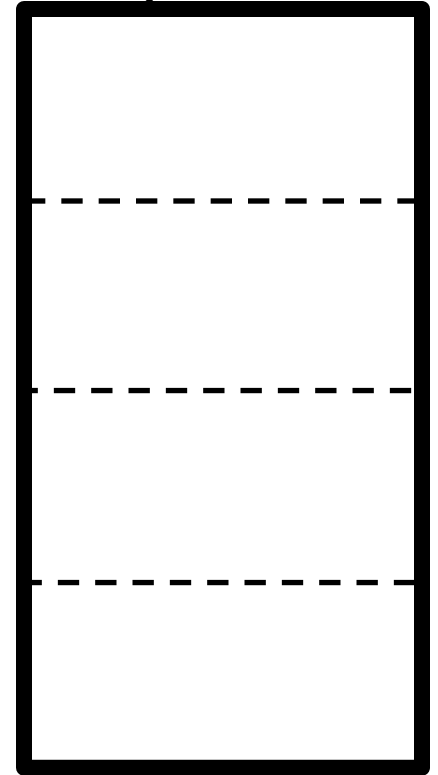
Virtual Page #: 43 →

Virtual Page #: 8 →

Virtual Page #: 99 →

Virtual Page #: 33 →

Virtual Page #: 99 →

Virtual Page #: 17 →

Physical RAM

Page Eviction

Virtual Page #: 17 →

Virtual Page #: 33 →

Virtual Page #: 40 →

Virtual Page #: 17 →

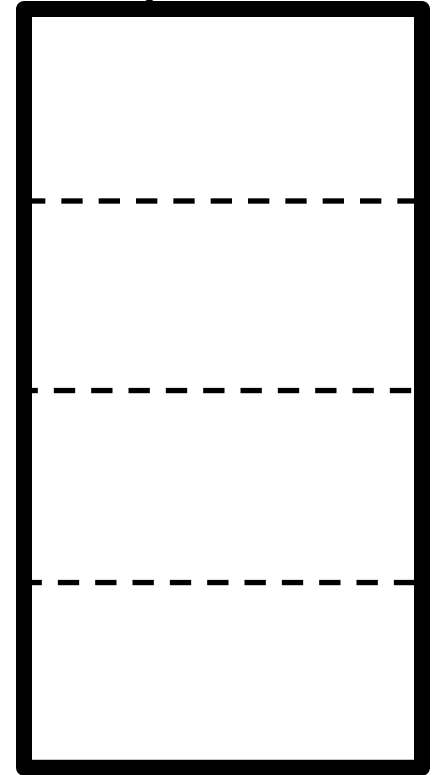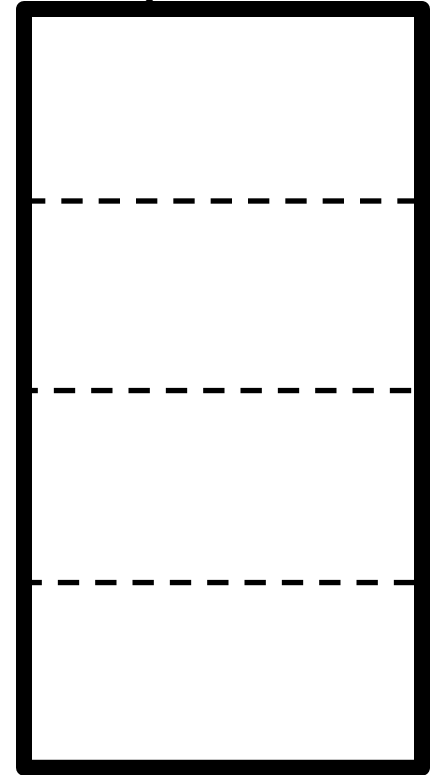Virtual Page #: 43 →

Virtual Page #: 8 →

Virtual Page #: 99 →

Virtual Page #: 33 →

Virtual Page #: 99 →

Virtual Page #: 17 →

Physical RAM

Status Bit #2

- **Accessed (A)** Bit:
  - This bit denotes if the page has been recently accessed.

  - **A=1**: The page has been recently accessed.
  - **A=0**: The page has not been recently accessed.
    - When the PTE is accessed, the R bit is set to 1. The MMU will scan page tables when memory is needed. When the MMU scans the memory:
      - If R=1, R is set to 0.
      - If R=0, page is evicted.

Status Bit #3

- **Dirty (D)** Bit:
  - Denotes if the page has been written to, and needs to be updated on disk when paged out.

  - **D=1**: The page is "dirty" and needs to be written to disk when paged out.

  - **D=0**: The page is "clean" and does not need to be written to disk when paged out.

Status Bit #4

- **Read/Write (R)** Bit:
  - Denotes if the page is read-only or read/write.

  - **R=1**: The page is read/write.
  - **R=0**: The page is read-only.
    - Areas of memory when the binary source of the process is located would be read-only.

Status Bit #5

- **Never eXecute (NX)** Bit:
  - Denotes if the page's content should never execute code.

  - **NX=1**: The content of the page should never be executed
  - **NX=0**: The content of the may be executed
    - Areas such as heap and stack memory, that should never contain executable code, would have NX=1.
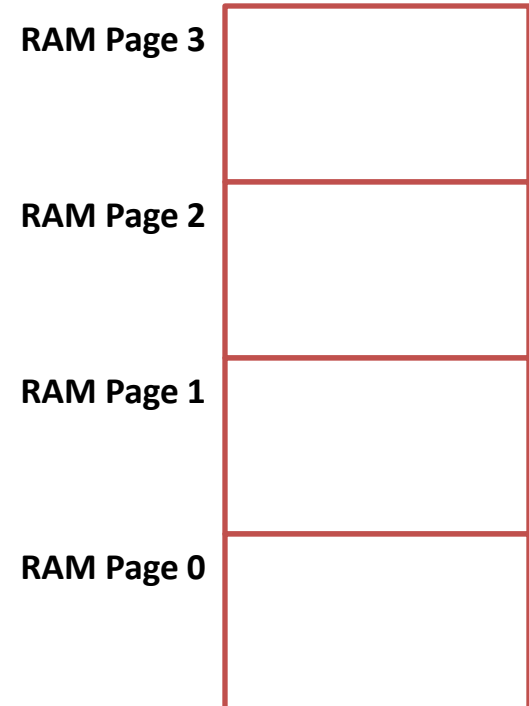
```
int subtract(int a, int *b) {
    int c = a - *b;
    return c;
}


int add(int a, int *b) {
    int c = a + *b;
    return c;
}


void main() {
    int a = 4;
    int *b = malloc(sizeof(int));
    *b = 7;
    int c = add(a, b);
    int d = subtract(c, b);
}
```
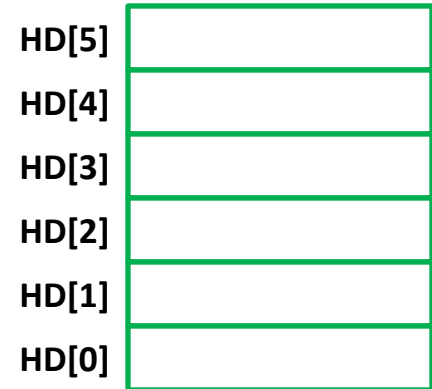
RAM

RAM Page 3

RAM Page 2

RAM Page 1

RAM Page 0

Page Tabe

Virtual Memory

	P	A	D	RW	NX	PAGE
[100]						
[99]						
[98]						
[3]						
[2]						
[1]						
[0]						

Hard Drive

HD[5]

HD[4]

HD[3]

HD[2]

HD[1]

HD[0]