Heap Memory Wrap-up and Page Tables

CS 241

Sept. 13, 2013

Strategy Comparison

- **Overhead**:
  - Dictionary:
  - Metadata:
  - Buddy System:

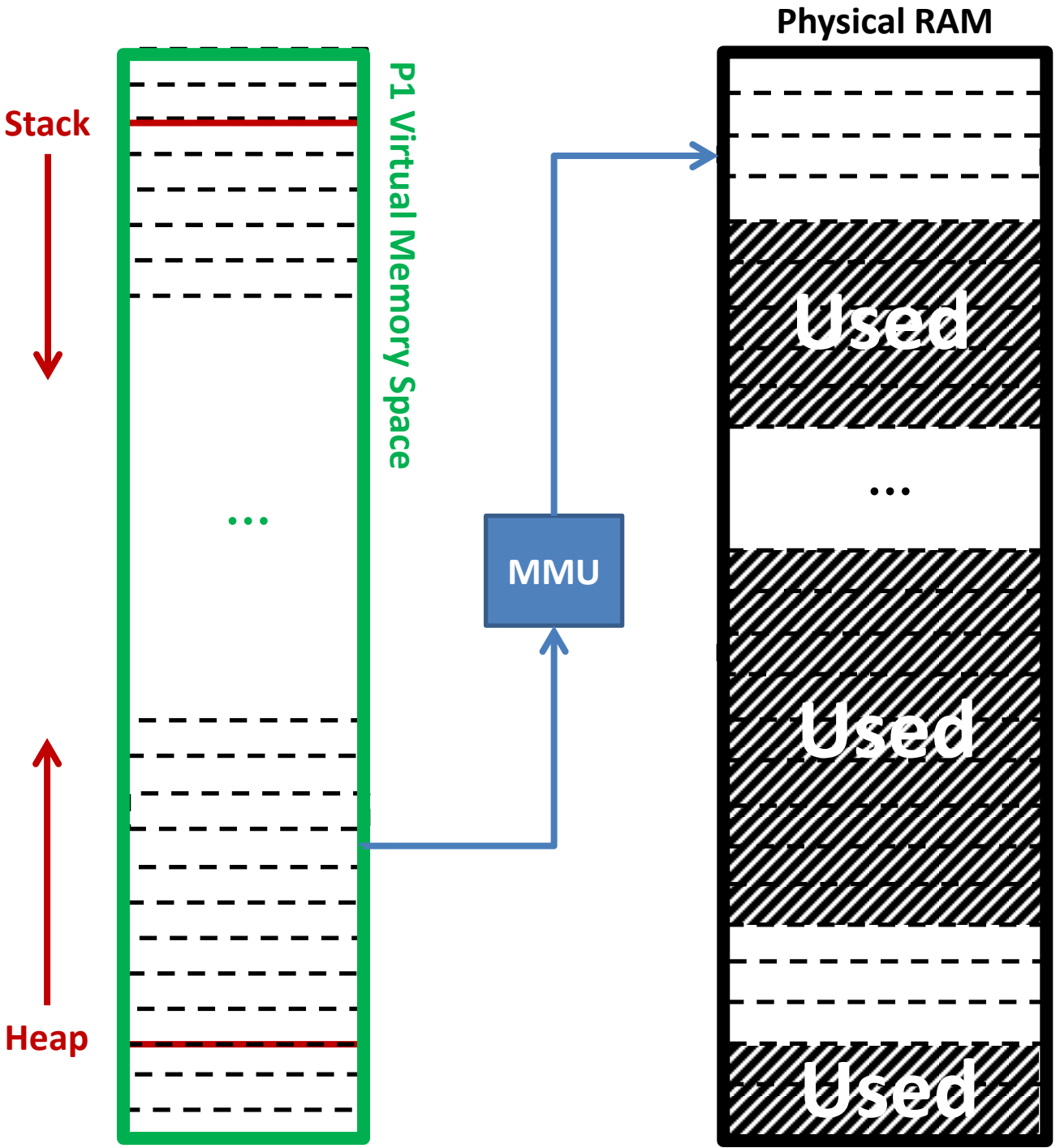
- **Unusable Space** (“Internal Fragmentation”):
  - Dictionary:
  - Metadata:
  - Buddy System:

Strategy Comparison

- **Find a "best fit" on malloc()**:
  - Dictionary:
  - Metadata:
  - Buddy System:

- **Find `p` in data structure on `free(p)`** :
  - Dictionary:
  - Metadata:
  - Buddy System:

MP2


Physical RAM
Stack
P1 Virtual Memory Space
MMU
Used
Used
Used
Heap

Virtual to Physical Address

- The OS divides every virtual and physical address into **pages**, fixed sized regions of memory.
  - Common page size: 4 KB

- Every virtual memory address can be viewed as two components:
  - **Page table index**: where in the page table is our data?
  - **Page table offset**: where in the page is our data?

Virtual to Physical Address

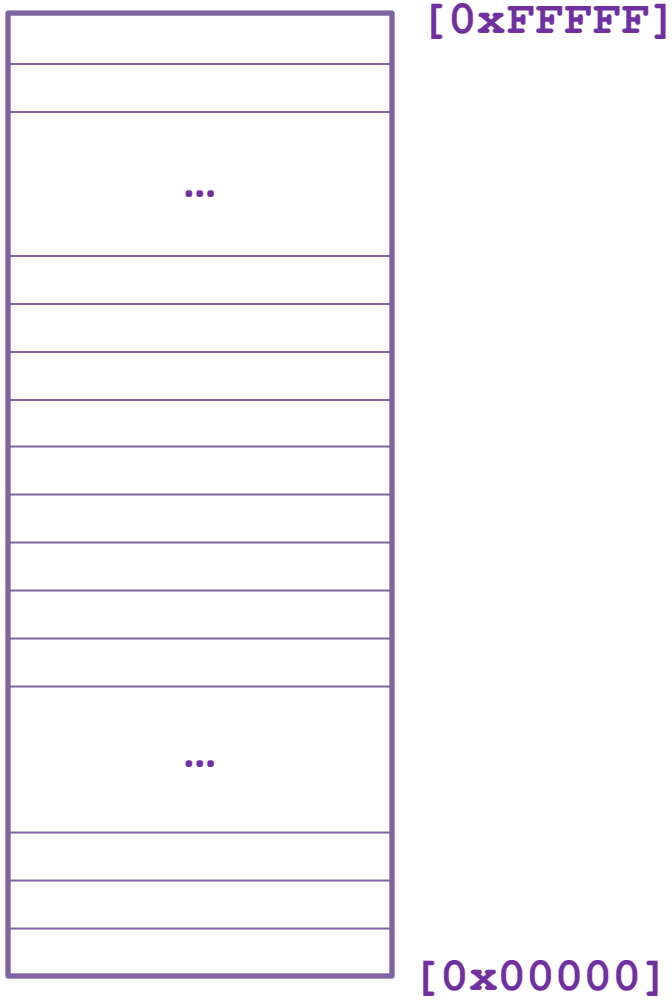
- Assuming a page size of 4 KB, identify page table index and offset of the following addresses:

0x a94c3013

0b 10010101000111110101000011

Page Table

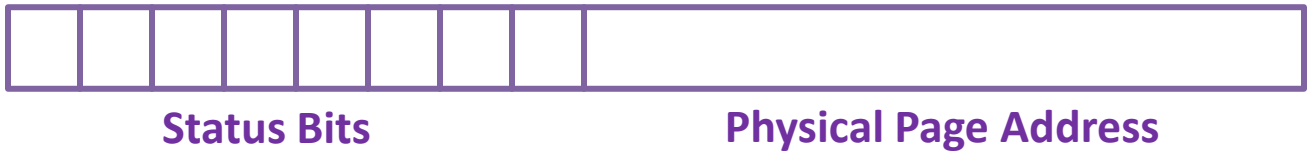
0x a94c3013



Page Size: 4 KB, Virtual Memory Address: 32-bit

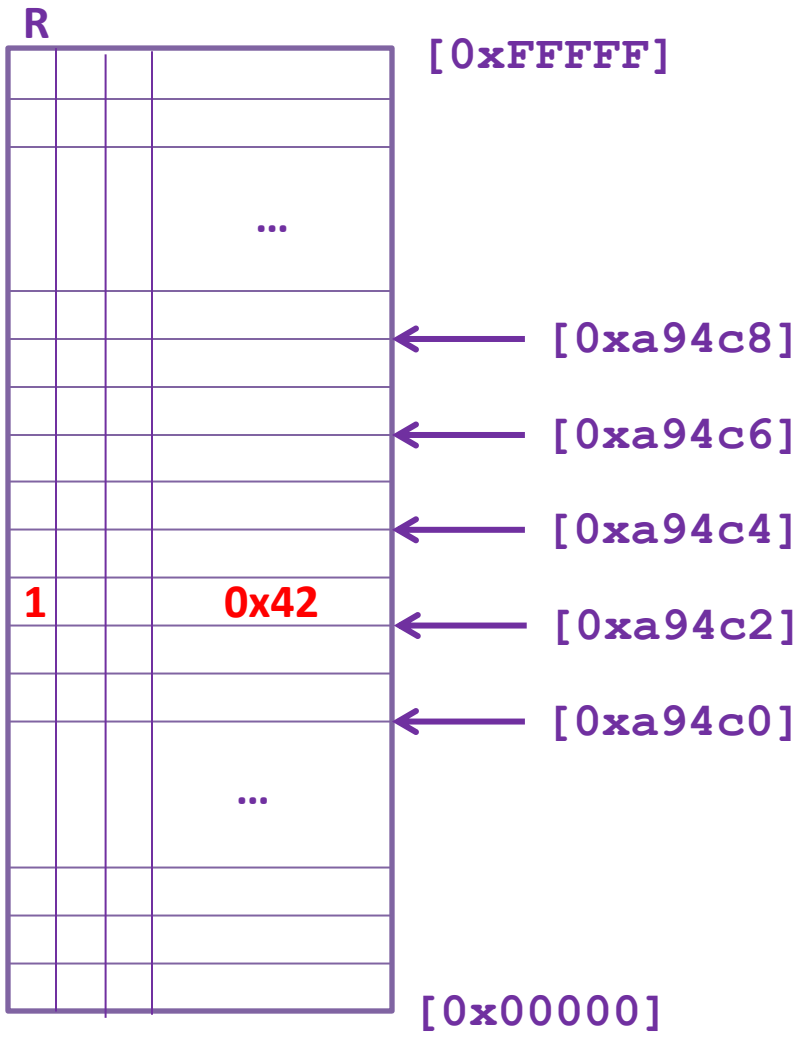
Page Table Entries (PTE)

- Every PTE consists of information to help translate the virtual address into the physical address.



Page Table

0x a94c3013



Page Size: 4 KB, Virtual Memory Address: 32-bit

Status Bit #1

- **Present (P)** Bit:
  - This bit denotes if the page is in physical memory (RAM) or on disk.
  - **P=1**: The page is in physical memory.
  - **P=0**: The page in not in physical memory.
    - If a page is not present in memory and needs to be accessed, a **page fault** occurs.

Page Fault

- A page fault occurs when a page needs to be brought from disk into physical memory.

- Several steps:
  1. Look at the physical page address in the PTE. This contains the location on disk of the data.
  2. Find an empty page in physical memory.
     - If there is no empty page in physical memory, we will need to evict a page.
  3. Load the data from disk into physical memory.
  4. Update the PTE.

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