IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

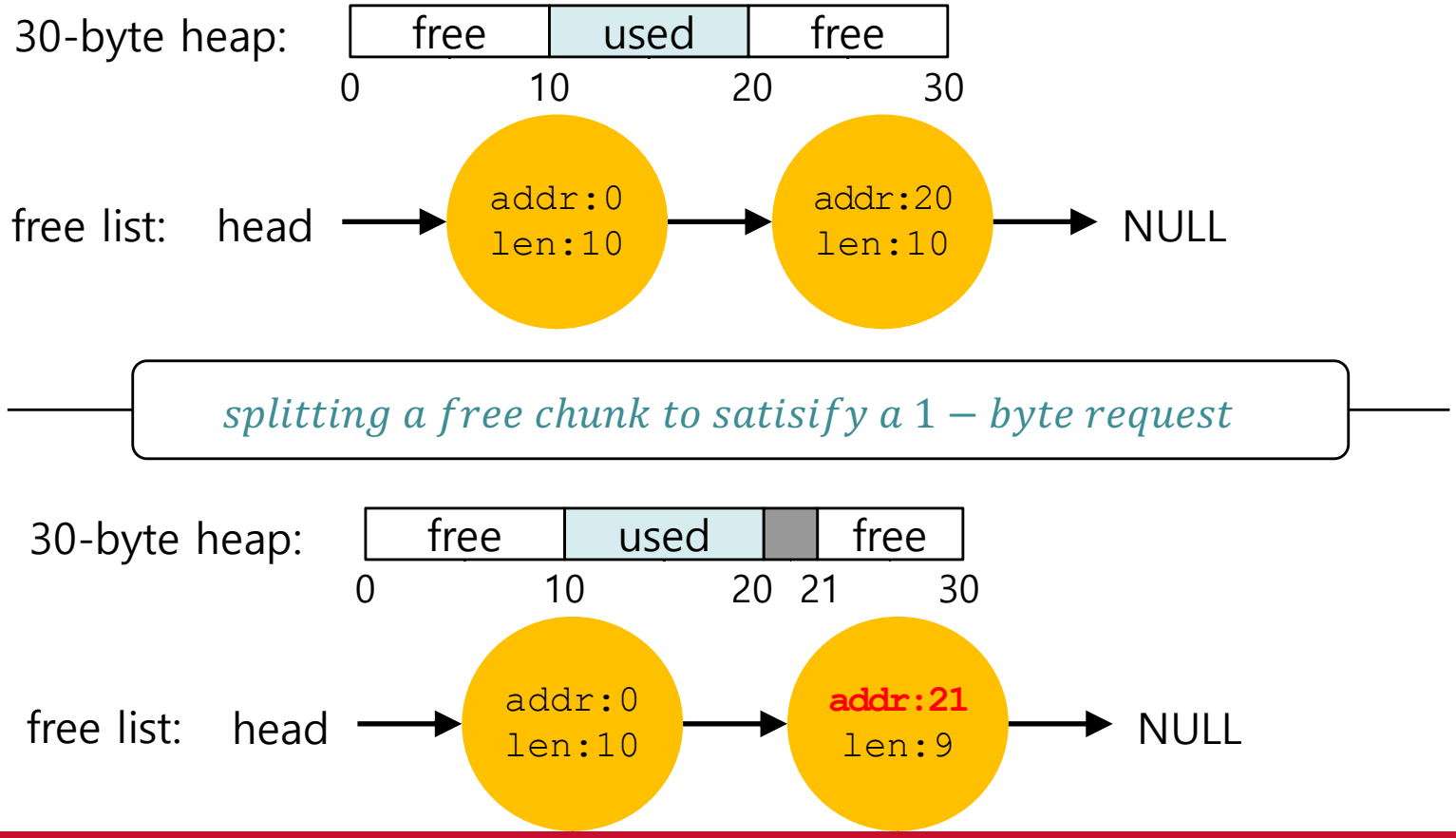
Lecture 20: Paging

Agenda

- Recap
- Paging
  - Address Translation
- Midterm 1 Feedback

Recap

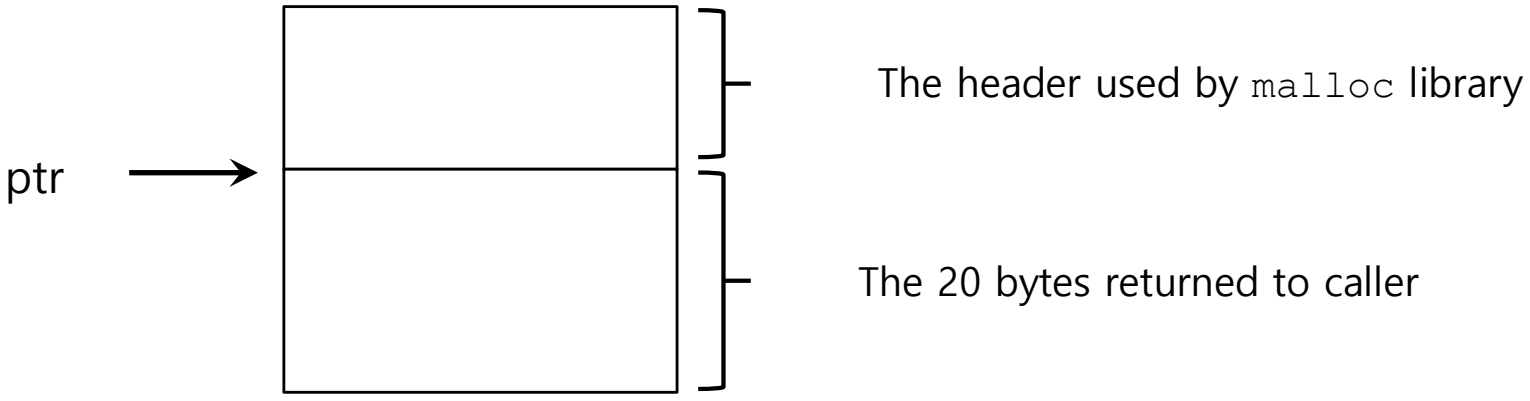
- Free-Space Management
  - Linked list (version 2): link free chunks



Recap

- Free-Space Management
  - Linked list (version 2): link free chunks
    - tracking the size of allocated regions via headers
      - The size of the allocated region is the size of the header plus the size of the space allocated to the user.

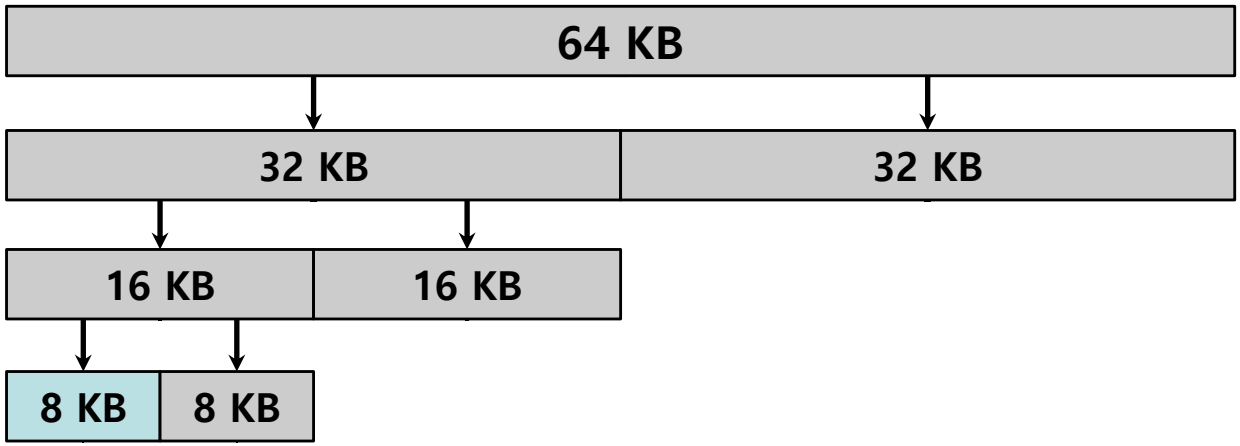
```
ptr = malloc(20);
```



An Allocated Region Plus Header

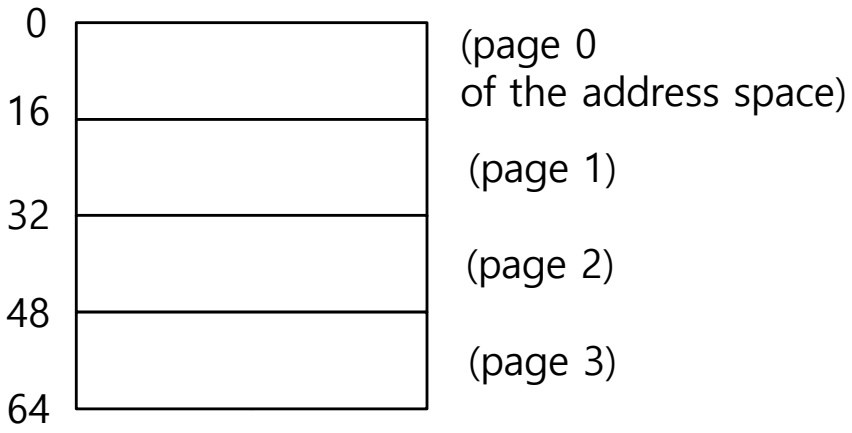
Recap

- Free-Space Management
  - Segregated List
    - Keeping free chunks in different size in a separate list for the size of popular request.
    - **Slab allocator**
  - Buddy Allocation

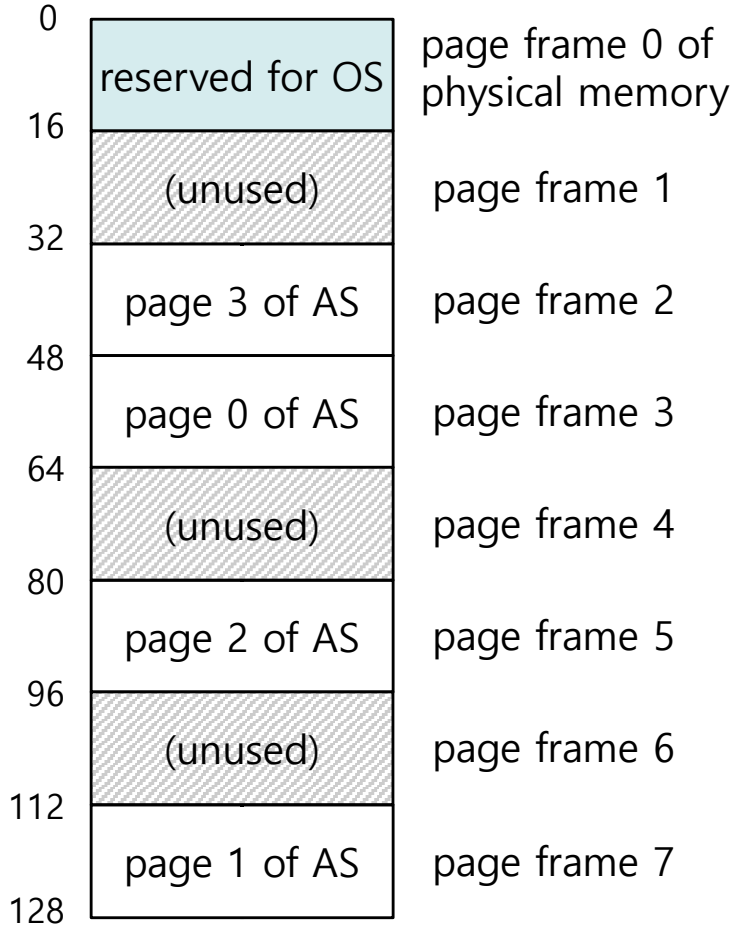


Recap

- Paging Concepts
  - split up address space into fixed-size units called ***pages***
    - physical memory is also split into fixed-size units called ***page frames***
    - Flexibility & simplicity



64-Byte Address Space



128-Byte Physical Memory

Agenda

- ~~Recap~~
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  - Address Translation
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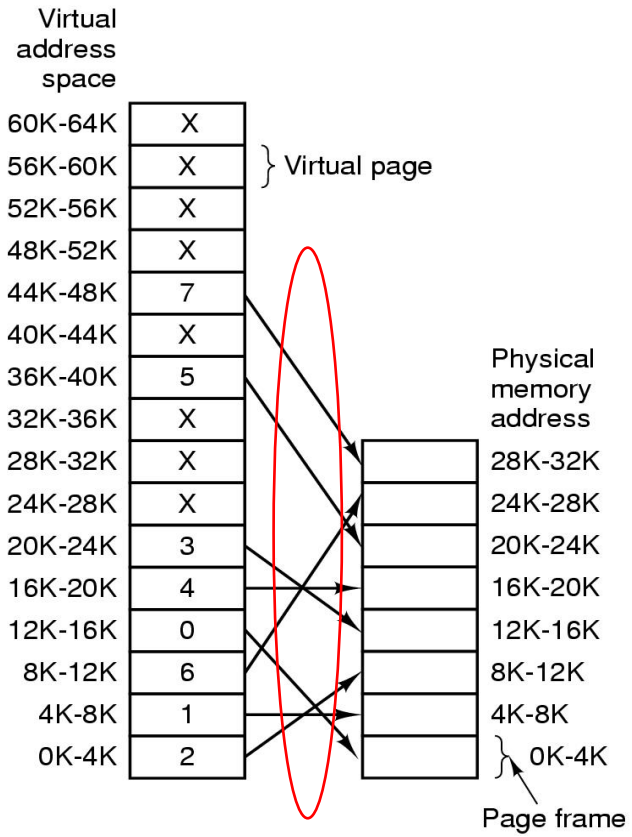
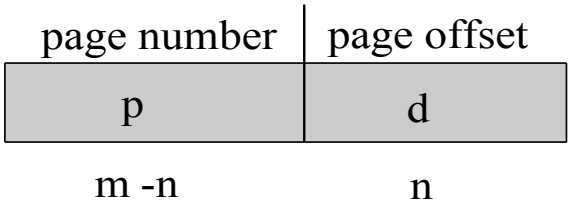
Address Translation

- How to map a virtual address (logical address) to a physical address in paging?



Address Translation

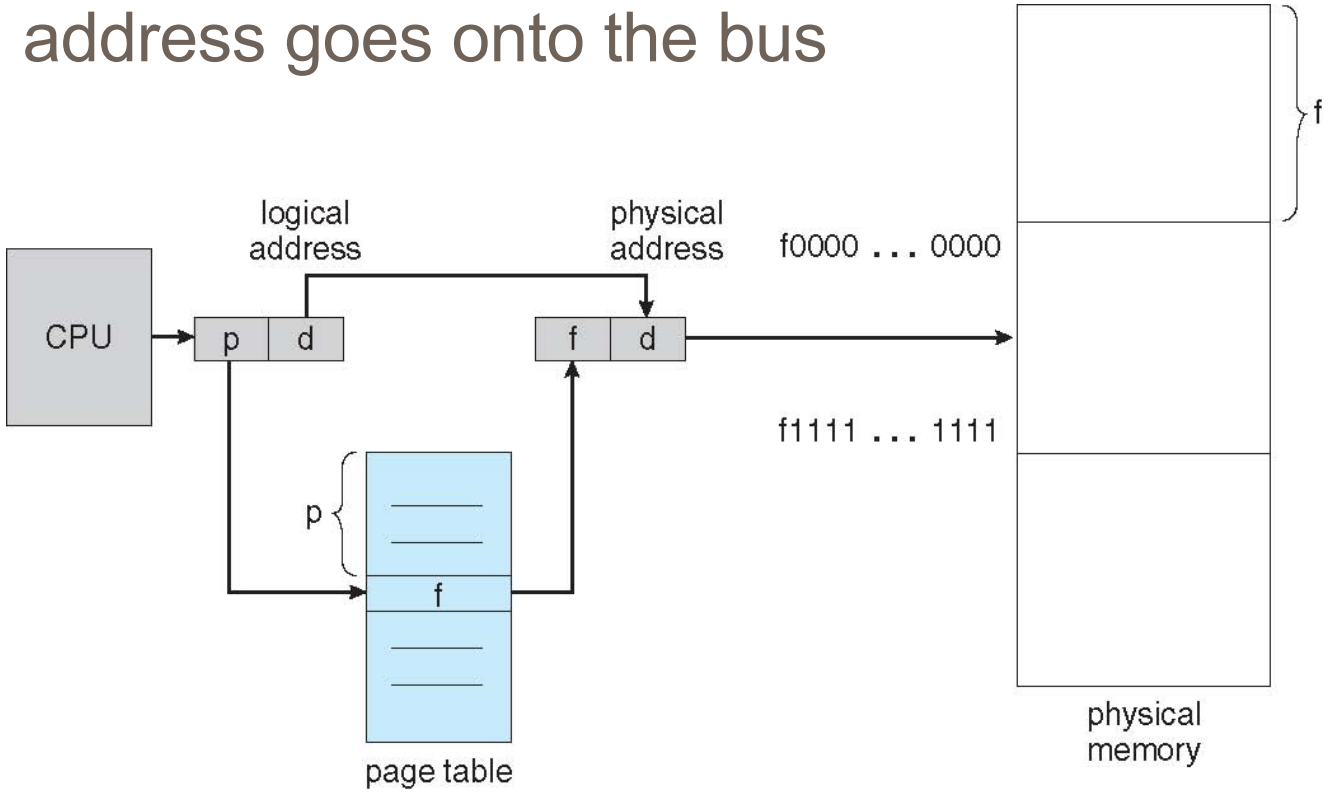
- Use a **page table**
  - contains the base address of each page in physical memory
  - each process has its own page table
- Each virtual address is divided into two parts:
  - VPN: virtual page number (p)
    - used as an index into the **page table**
  - Offset: offset within the page (d)



  - E.g., a 2^m bytes address space with page size 2^n

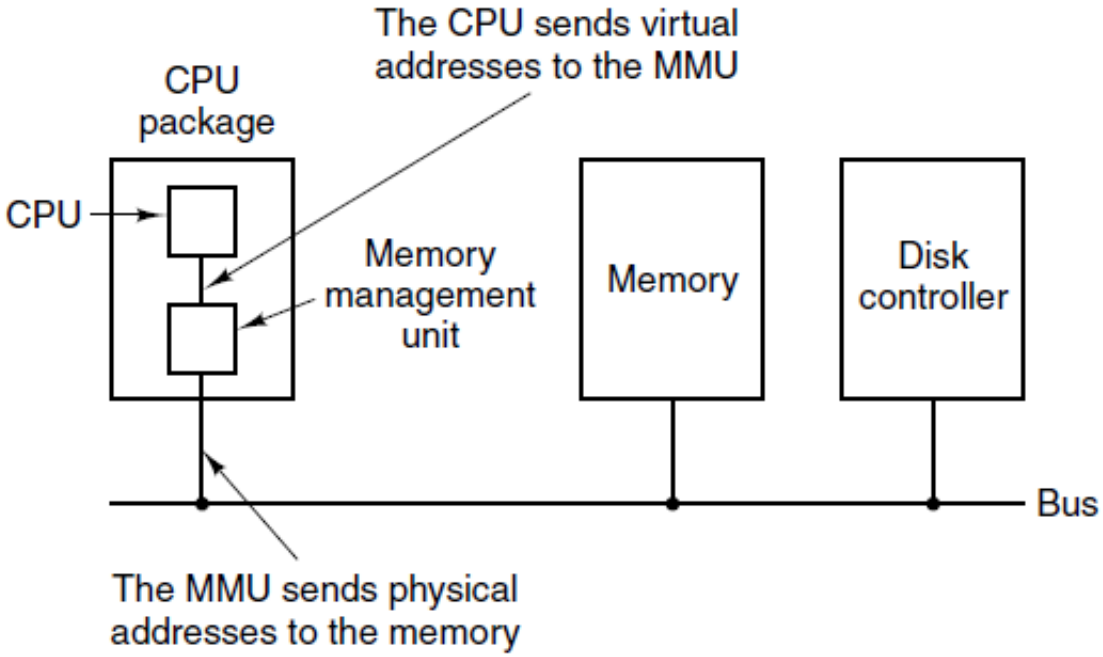
Address Translation

- Paging hardware
  - Process generates a virtual address (logical address)
  - Virtual address is translated into a physical address
  - Physical address goes onto the bus



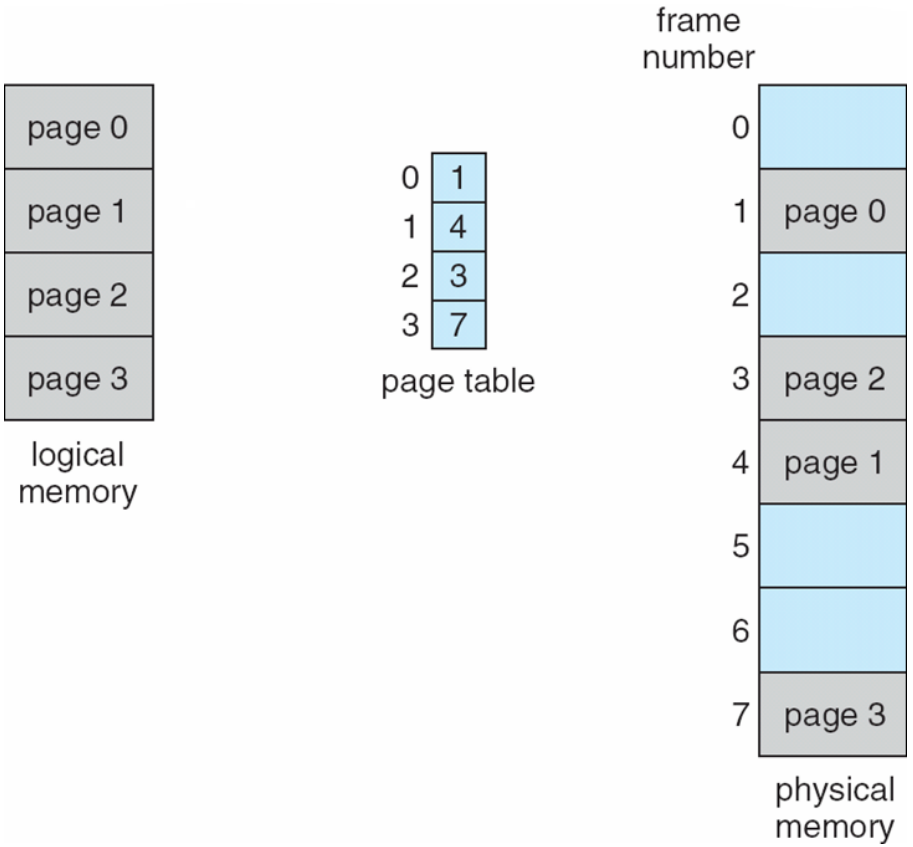
Address Translation

- Paging hardware
  - Memory management unit (MMU)



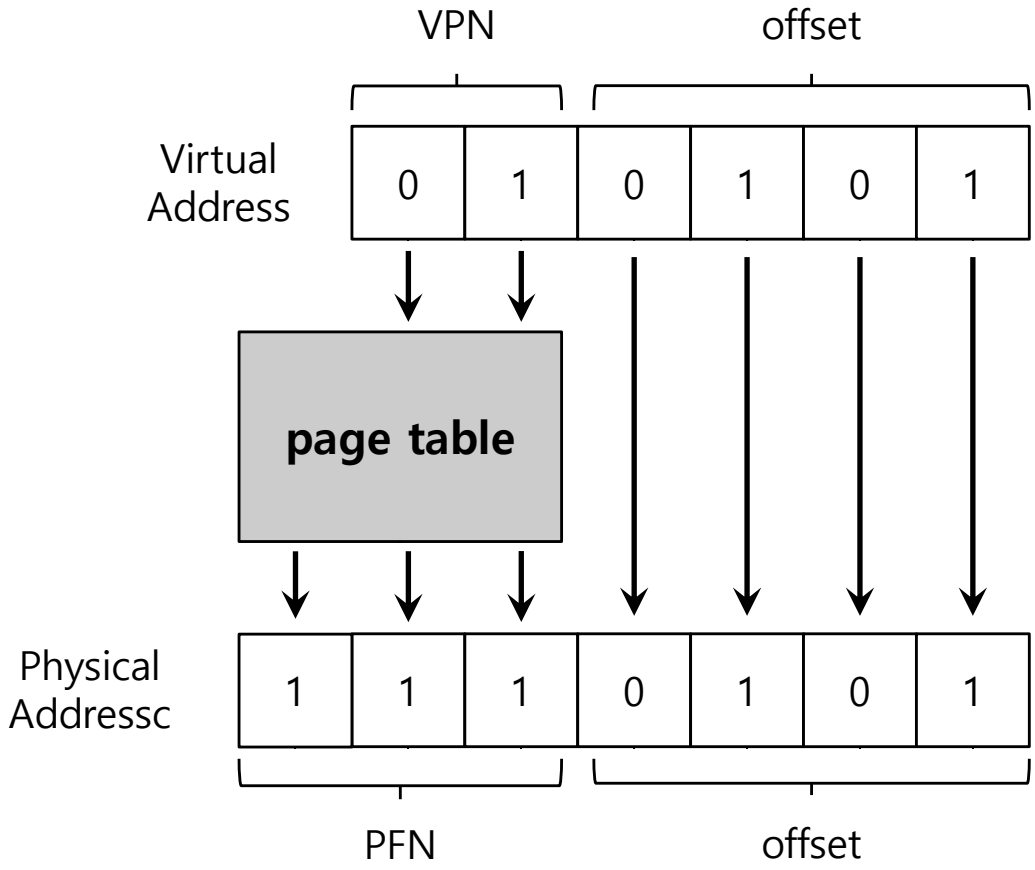
Address Translation

- Paging examples
  - 4-page address space to 8-frame physical memory



Address Translation

- Paging examples
  - The virtual address 21 in 64-byte address space
    - 64 = 2^6
    - 21: 0x010101



Agenda

- ~~Recap~~
- ~~Paging~~
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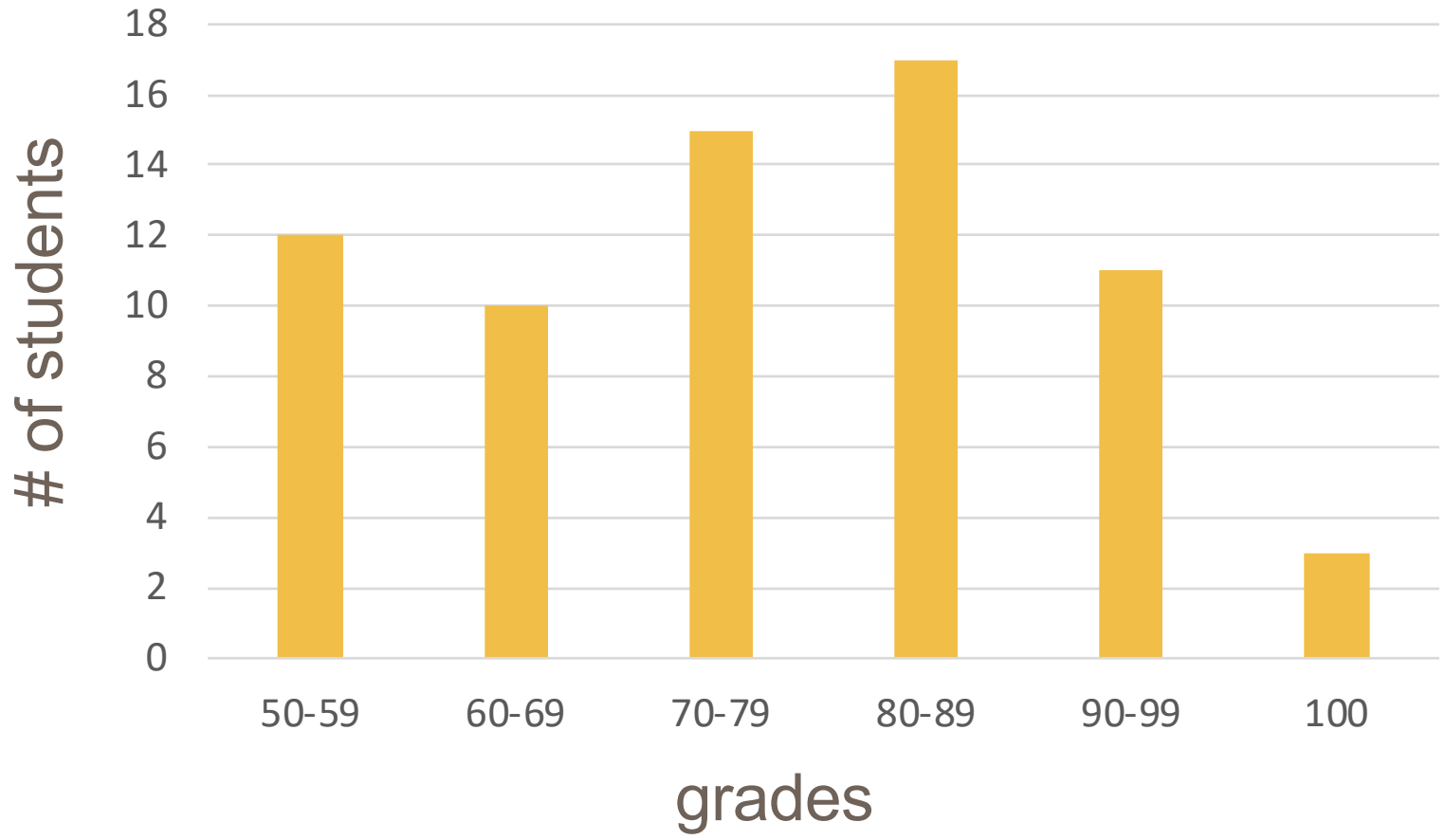
Midterm 1 Feedback

- Overview



Midterm 1 Feedback

- Some observations
  - Top scorers
    - attended the class regularly
    - participated in Q&A actively
  - Those sent emails to me about class participation are above average in general
    - followed the instructions

Midterm 1 Feedback

- If you did not do well ...

Midterm 1 Feedback

- If you did not do well ...
  - Don’t lose heart
    - Midterm 1 only accounts for 10% of your final grade
    - OS (and systems in general) is a very practical area
      - score on paper does not necessarily indicate your potential in practice

Midterm 1 Feedback

- If you did not do well ...
  - Don’t lose heart
    - Midterm 1 only accounts for 10% of your final grade
    - OS (and systems in general) is a very practical area
      - score on paper does not necessarily indicate your potential in practice
  - You may want to adjust your study method to secure a high GPA
    - Attend class (more regularly)
    - Ask questions (more frequently)
    - Visit office hours (more frequently)
    - Spend (more) time
    - ...