VIRTUAL MEMORY

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Overview

- Announcement
  - Homework 6 will be released tonight (due on 11/10)

- This and next lectures
  - Virtual memory
  - Page tables and address translation
  - Translation look-aside buffer (TLB)
  - Main memory system
Recall: Memory Hierarchy

- Lower levels provide greater capacity longer time
  - Does the program fit in main memory?
  - What if running multiple programs?

- Cache
  - Capacity: 8MB
  - Time: ~20 ns

- Main Memory
  - Capacity: 8GB
  - Time: ~250 ns

- Secondary Memory
  - Capacity: 500GB
  - Time: ~10 ms
Virtual Memory

- Use the main memory as a “cache” for secondary memory
  - Placement policy?

```c
for(i=0; i<100;++i) {
    a[i]++;
}
```
Virtual Memory

- Use the main memory as a “cache” for secondary memory
  - Placement policy?
- Allow efficient and safe sharing the physical main memory among multiple programs
  - Replacement policy?

```c
for(i=0; i<100;++i) {
    a[i]++;
}
```

```c
for(i=0; i<200;++i) {
    a[i]=a[i]+i;
}
```
Virtual Memory Systems

- Provides illusion of very large memory
  - Address space of each program larger than the physical main memory
- Memory management unit (MMU)
  - Between main and secondary mem.
  - Address translation
    - Virtual address space used by the program
    - Physical address space is provided by the physical main memory
Virtual Address

- Every virtual address is translated to a physical address with the help of hardware

- Data granularity