Lecture 8: Mechanism of Address Translation

Mythili Vutukuru

IIT Bombay

A simple example

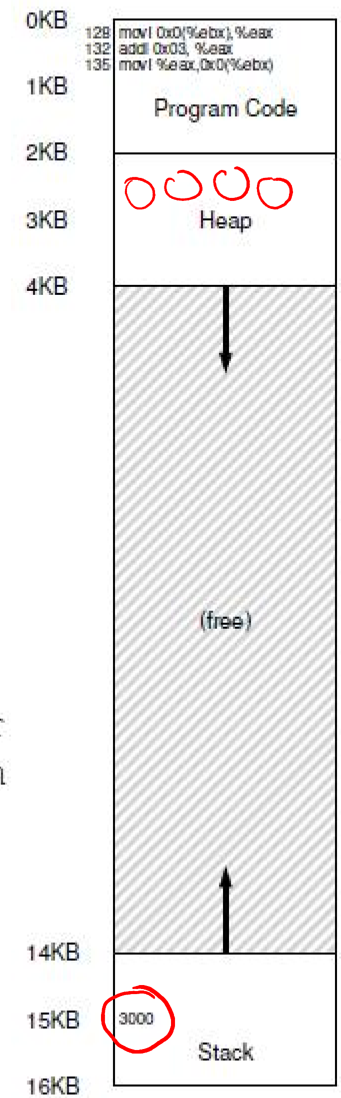
- Consider a simple C function

```
void func() {
    int x = 3000; //
    x = x + 3;
```

- It is compiled as follows

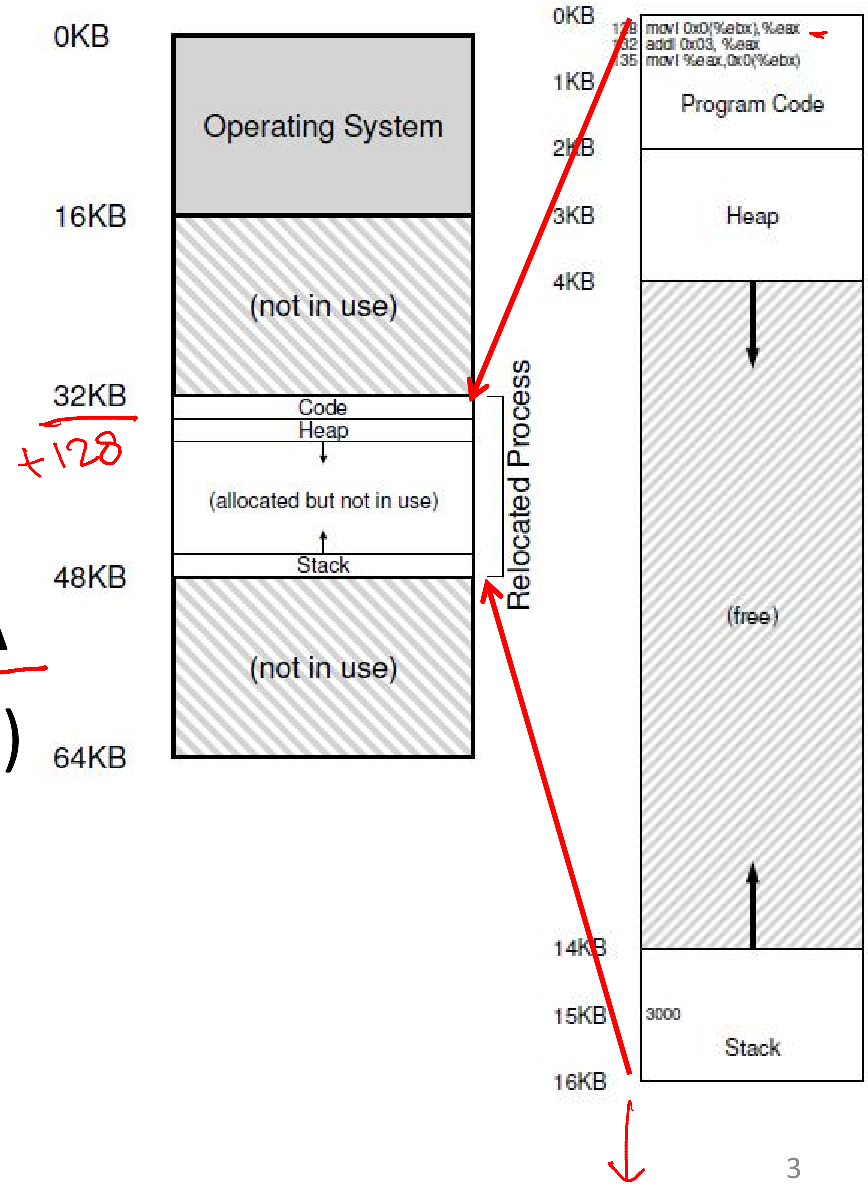
```
128: movl 0x0(%ebx), %eax      ;load 0+ebx into eax
132: addl $0x03, %eax          ;add 3 to eax register
135: movl %eax, 0x0(%ebx)      ;store eax back to mem
```

- Virtual address space is setup by OS during process creation



Address Translation

- Simplified OS: places entire memory image in one chunk
- Need the following translation from VA to PA
  - 128 to 32896 (32KB + 128)
  - 1KB to 33 KB
  - 20KB? Error!



Who performs address translation?

- In this simple example, OS tells the hardware the base (starting address) and bound (total size of process) values
- Memory hardware Memory Management Unit (MMU) calculates PA from VA

```
physical address = virtual address + base
```

- MMU also checks if address is beyond bound
- OS is not involved in every translation

Role of hardware in translation

- CPU provides privileged mode of execution
- Instruction set has privileged instructions to set translation information (e.g., base, bound)
- Hardware (MMU) uses this information to perform translation on every memory access
- MMU generates faults and traps to OS when access is illegal (e.g., VA is out of bound)

Role of OS in translation

- OS maintains free list of memory
- Allocates space to process during creation (and when asked) and cleans up when done
- Maintains information of where space is allocated to each process (in PCB)
- Sets address translation information (e.g., base & bound) in hardware
- Updates this information upon context switch
- Handles traps due to illegal memory access

Segmentation

- Generalized base and bounds
- Each segment of memory image placed separately
- Multiple (base, bound) values stored in MMU
- Good for sparse address spaces
- But variable sized allocation leads to external fragmentation
  - Small holes in memory left between segments