Memory Management (2)

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CSE325 Principles of Operating Systems

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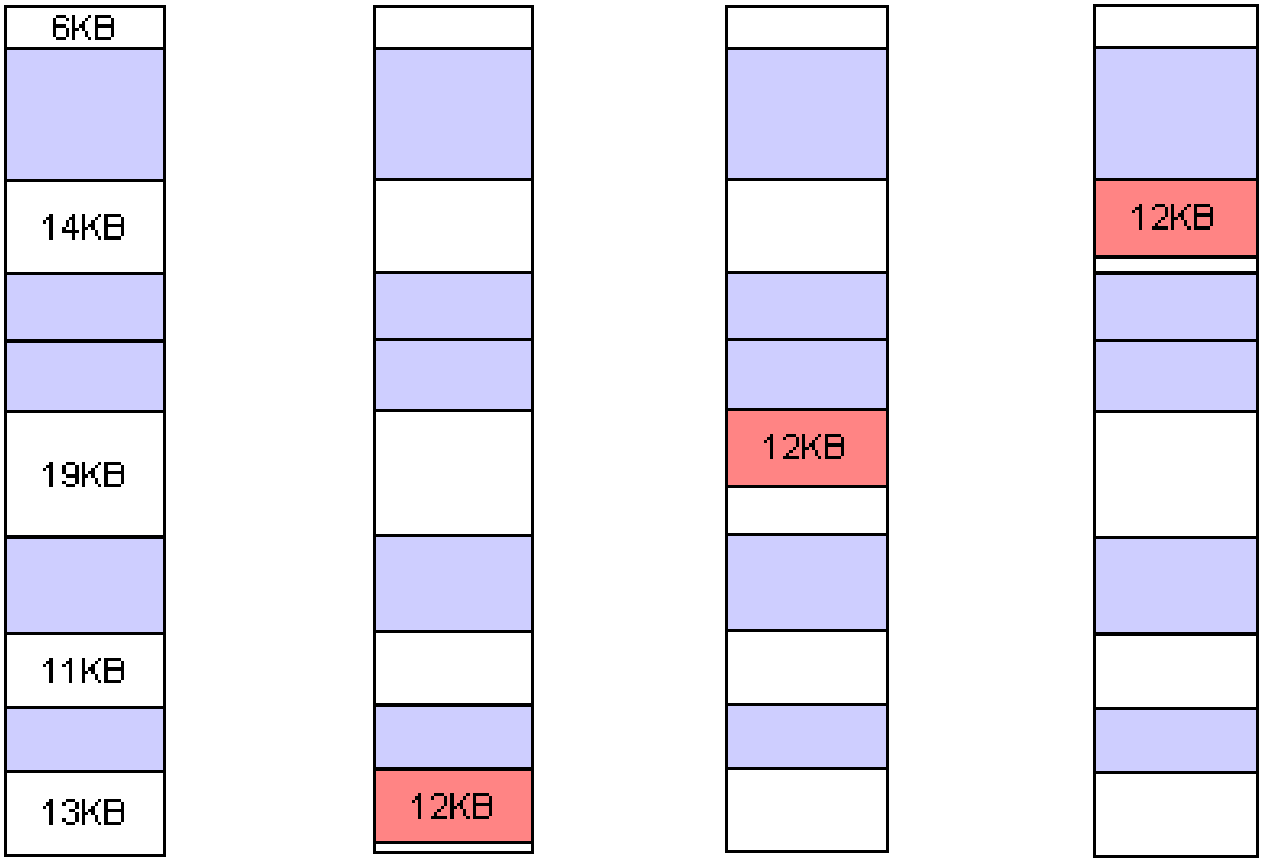
Allocation Example



Memory Best-fit Worst-fit First-fit

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In-class Work 5

Give five memory partitions of 100KB, 500KB, 200KB, 300KB and 600KB (in order), how would each of the first-fit, best-fit, and worst-fit algorithms place processes of 212KB, 417KB, 112KB, and 426KB (in order)? Which algorithm makes the most efficient use of memory?

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Fragmentation

- **External Fragmentation** – total memory space exists to satisfy a request, but it is not contiguous
- **Internal Fragmentation** – allocated memory may be slightly larger than requested memory; this size difference is memory internal to a partition, but not being used

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Fragmentation (Cont.)

- Reduce external fragmentation by **compaction**
  - Shuffle memory contents to place all free memory together in one large block
  - Compaction is possible *only* if relocation is dynamic, and is done at execution time
- Another solution is to allow the logical address space of the processes to be noncontiguous.

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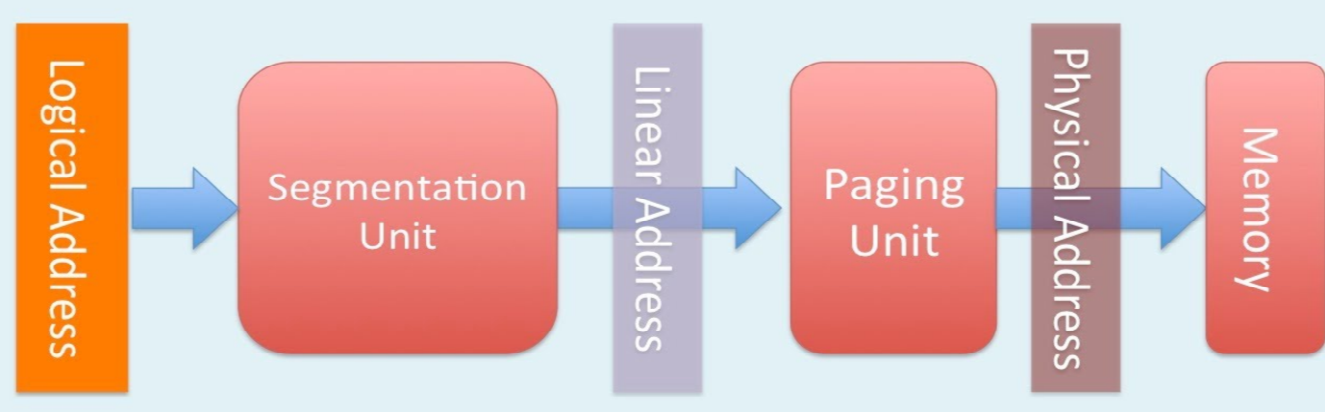
x86 Address Translation

- CPU generates virtual address `(seg, offset)`
  - Given to segmentation unit
    - Which produces linear addresses
  - Linear address given to paging unit
    - Which generates physical address in main memory



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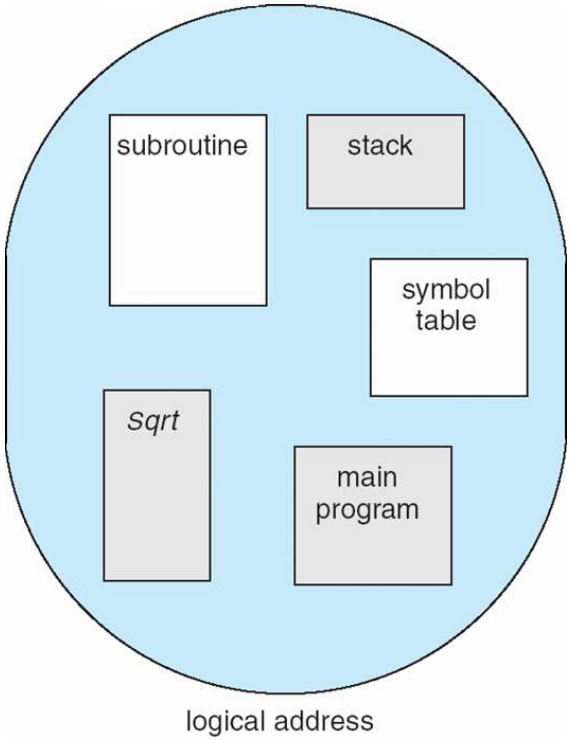
Segmentation

- Divide virtual address space into separate logical segments; each is part of physical memory.
- A natural extension of variable-sized partition
  - variable-sized partition = 1 segment/process
  - segmentation = many segments/process



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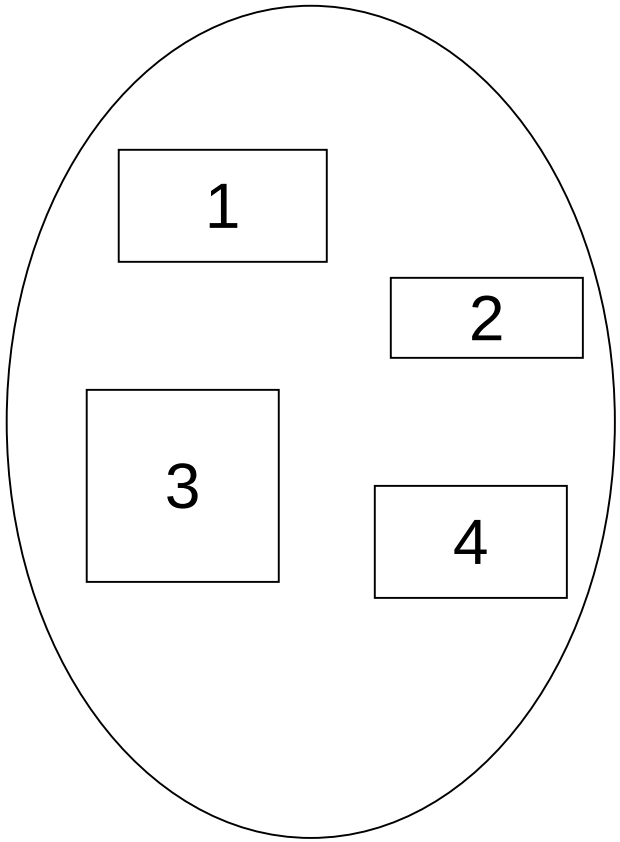
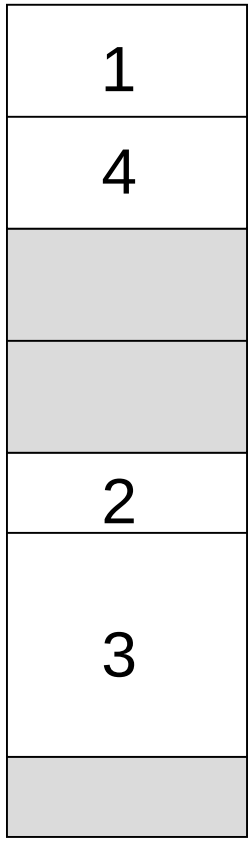
Logical View of Segmentation



user space



physical memory space

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Segmentation Translation

- Virtual address: `<segment-number, offset>`
- Segment table maps segment number to segment information
  - Base: starting address of the segment in physical memory
  - Limit: length of the segment
  - Addition metadata includes protection bits (validation bit, r/w/e priviledges etc.)
- Limit & protection checked on each access

x86 Segment Selector

- Logical address: segment selector + offset
- Segment selector stored in segment registers (16-bit)
  - `cs`: code segment selector
  - `ss`: stack segment selector
  - `ds`: data segment selector
  - `es,fs,gs`: extra
- Segment register can be implicitly or explicitly specified
  - Implicit by type of memory reference (`jmp`)
    - `mov $8049780, %eax` // implicitly use ds
  - Through special registers (`cs,ss,ds,es,fs,gs` on x86)
    - `mov %ss:$8049780, %eax` // explicitly use `ss`
- Support for segmentation removed in x86-64
  - `cs, ss, ds`, and `es` are forced to 0

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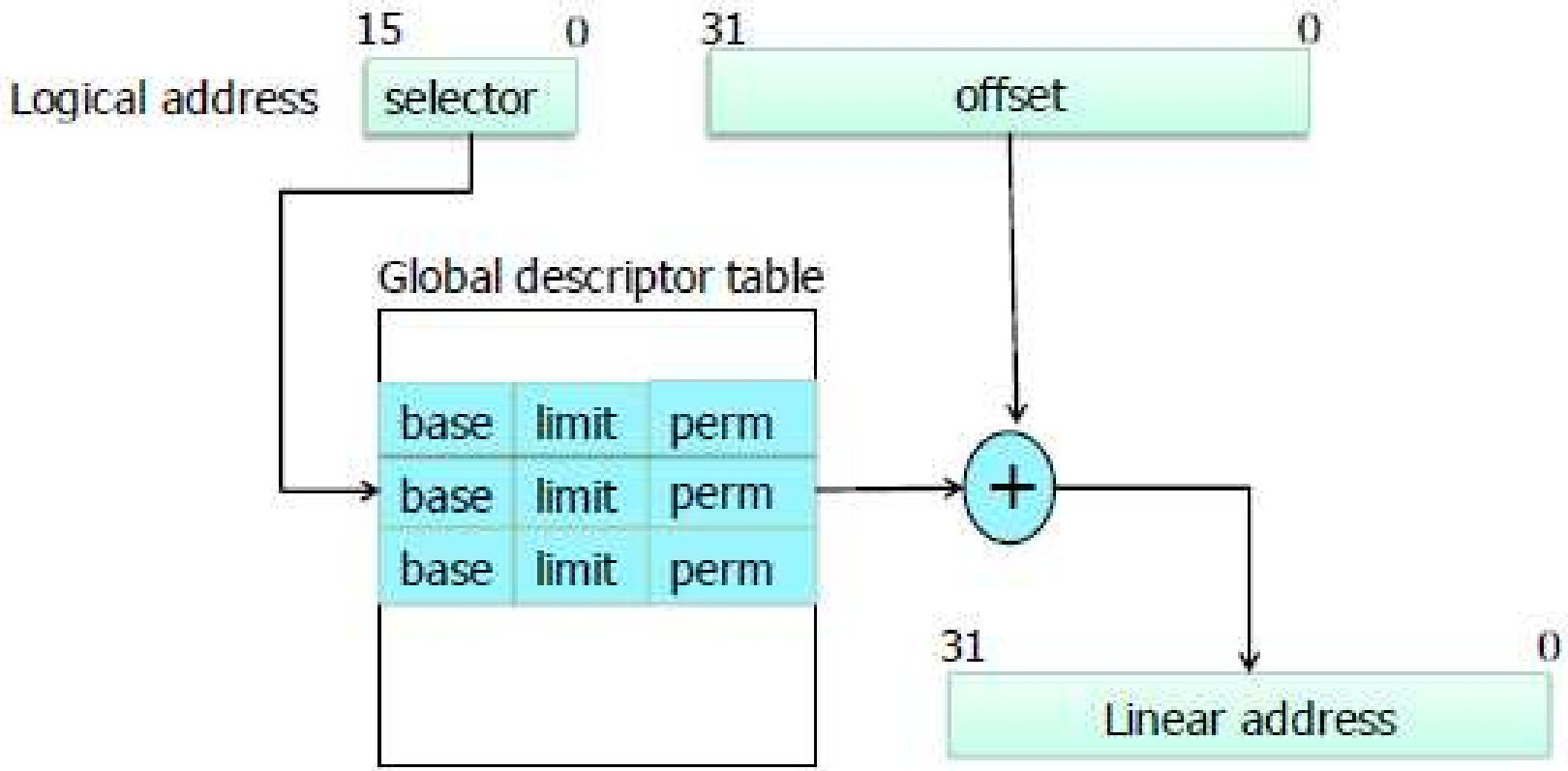
x86 Segmentation Hardware



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xv6 Segments

- `vm.c`, `ksegment()`

- Rely mainly on paging (like Linux)
- Kernel code: readable + executable in kernel mode
- Kernel data: writeable in kernel mode
- User code: readable + executable in user mode
- User data: writable in user mode
- These are all null mappings
  - Map to `[0, 0xFFFFFFFF]`
  - linear address = offset

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