This Week

- Easter Help Desk Hours
  - 10-17 April - No Help Desk
  - 20-24 April - 10-12AM, C405
  - 27 April - Normal hours resume
- No tutorial
- No homework

Virtual Memory

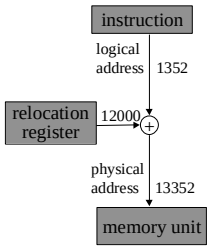
Comp 305, Lecture 6

This Week

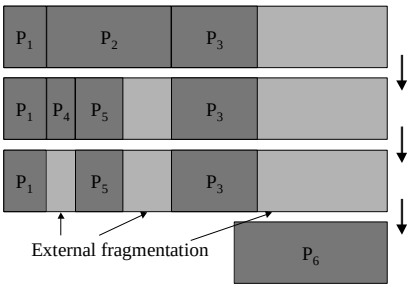
- Paging
- Segmentation
- Translation Lookaside Buffers

Logical v. Physical Address

- *Logical address* - generated by instruction
- *Physical address* - passed to memory unit
- *Virtual address* - logical address in systems where logical and physical differ



Fragmentation

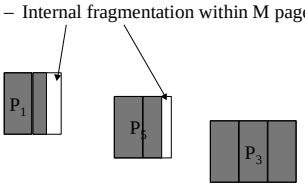


Paging - Physical Memory

- Allocate physical memory in page frames
  - 2^n frames
  - Each frame is 2^k addresses

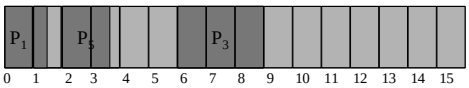
Paging - Logical Memory

- Process's logical memory is in pages
  - Each page is 2^k addresses
  - Internal fragmentation within M pages



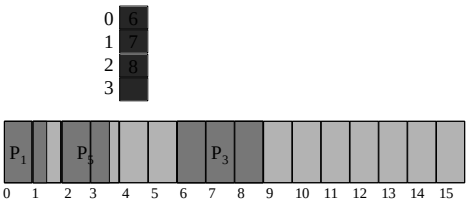
Mapping Logical to Physical

- Align pages with page frames



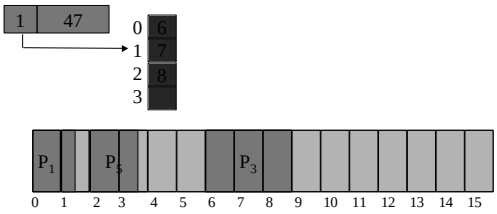
Mapping Logical to Physical

- Base register for each page frame



Mapping Logical to Physical

- Base register for each page frame
  - High order n bits select register



Mapping Logical to Physical

- Base register for each page frame
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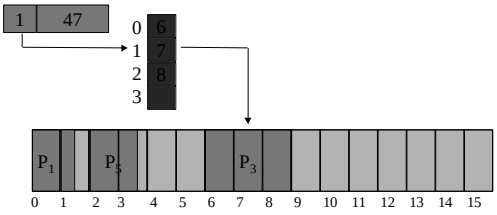
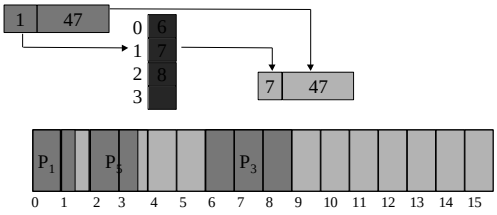


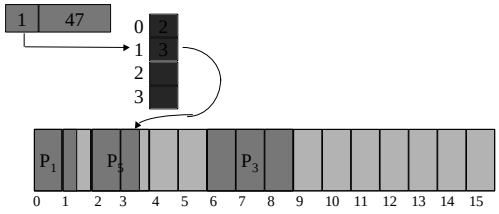
Building a Physical Address

- Translate page to page frame
- Copy address within page

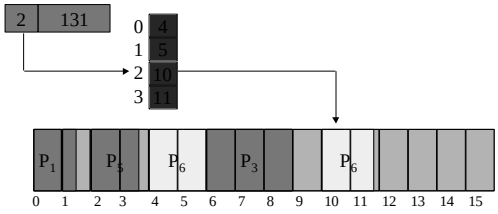


Context Switch

- Registers are part of context



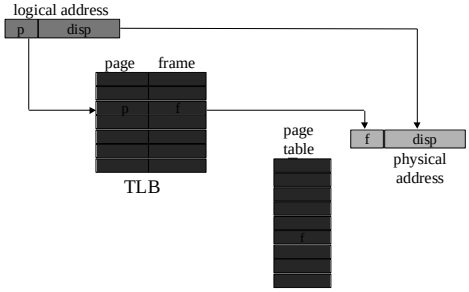
Non-Contiguous Memory



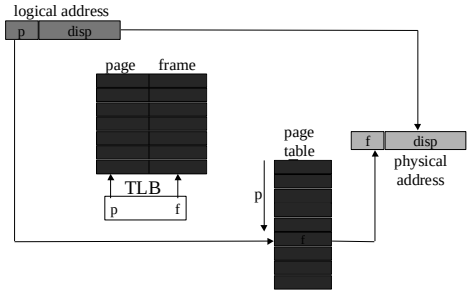
Performance Considerations

- Every access must go through page table
- Small page table → registers
- Large page table → table in memory
  - Access requires indexing page table
  - Then accessing memory
- Translation look aside buffer
  - "Associative cache"

Paging With A TLB



Paging With A TLB



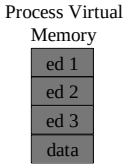
TLB Performance

- Assumptions

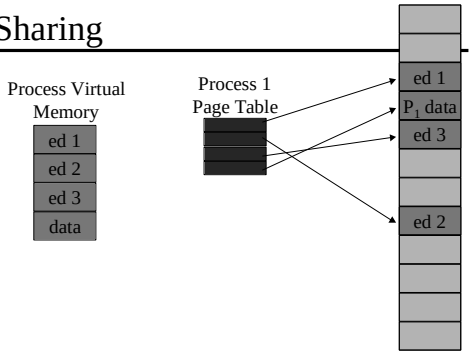
  memory access 100 nsec
  TLB access 20 nsec
- 90% "hit rate"

  .90 x (20 + 100) + .10 x (20 + 100 +100) = 130 nsec
- Context switch

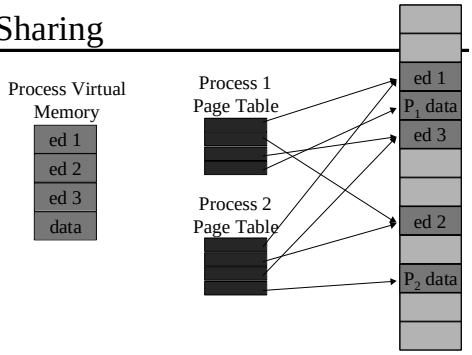
Sharing



Sharing

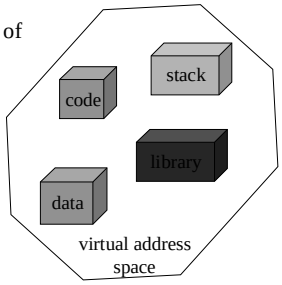


Sharing

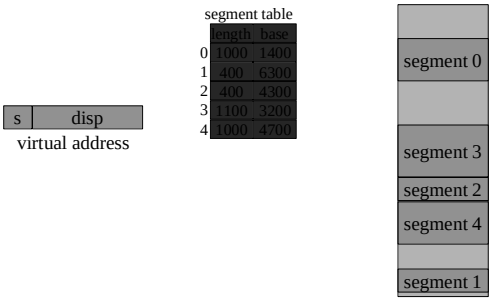


Segmentation

- Reflect logical view of process
- Facilitate sharing
- 2-dimensional



Segmentation: Virtual to Physical



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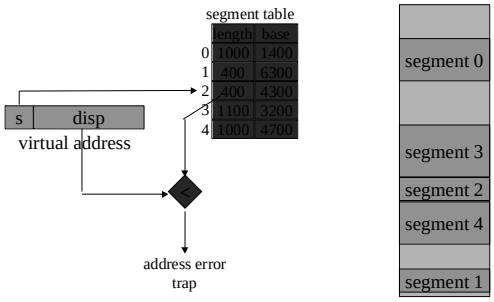

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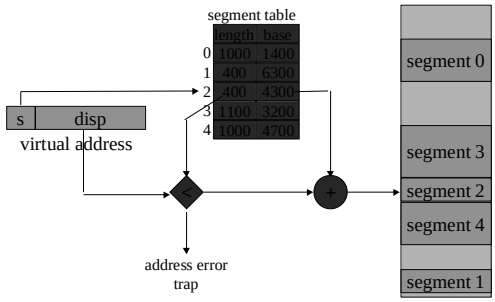
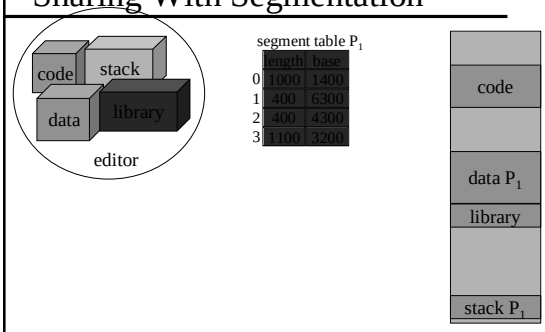
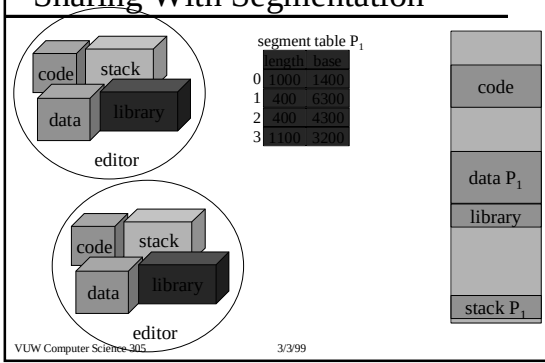


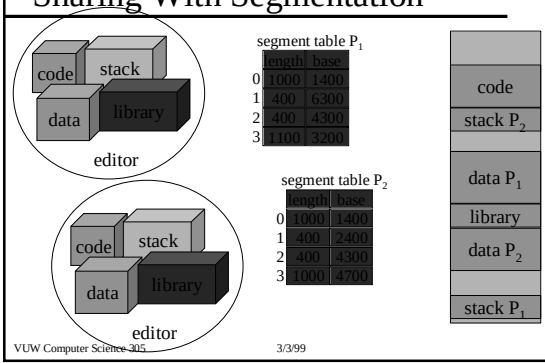
Sharing With Segmentation



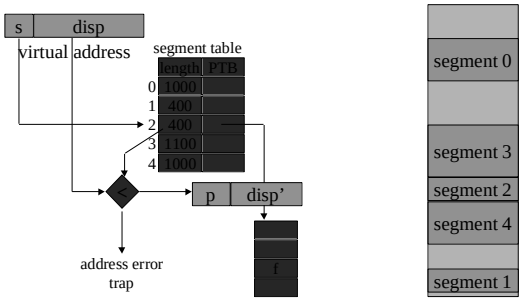
Sharing With Segmentation



Sharing With Segmentation



Segmentation With Paging



Segmentation With Paging