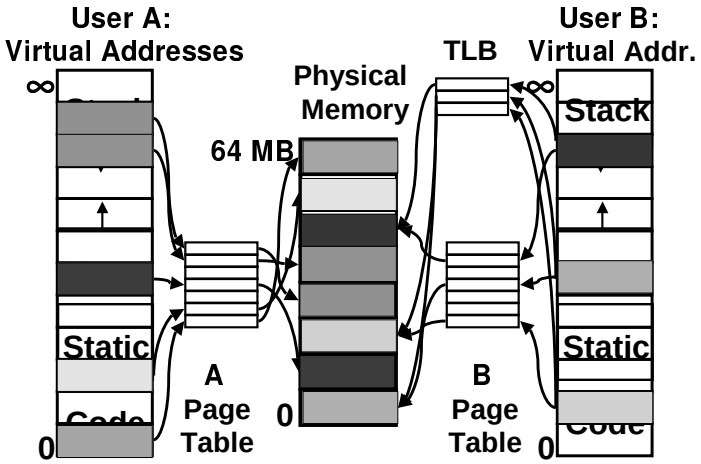
Paging/Virtual Memory Review



Why virtual memory?

- Protection
  - regions of the address space can be read only, execute only ...
- Flexibility
  - portions of a program can be placed anywhere in physical memory, without relocation
- Expandability
  - can leave room in virtual address space for objects to grow
- Efficient use of fast storage
  - retain only most important portions of the program in memory
- Can run programs larger than size of physical memory

Three Advantages of Virtual Memory

1) Translation:
   - Program can be given consistent view of memory, even though physical memory is scrambled
   - Makes multiple processes reasonable
   - Only the most important part of program ("Working Set") must be in physical memory
   - Contiguous structures (like stacks) use only as much physical memory as necessary yet still grow later
2) Protection:
   - Different processes protected from each other
   - Different pages can be given special behavior
     - (Read Only, Invisible to user programs, etc).
   - Kernel data protected from User programs
   - Very important for protection from malicious programs (viruses)
3) Sharing:
   - Can map same physical page to multiple users ("Shared memory")

TLB, Page Table

Memory lookup slow: TLB to reduce performance cost of VM

Need more compact representation to reduce memory size cost of simple 1-level page table, especially for 64-bit address

-64 bit address space, 4K pages => 2^52 entries in the page table

Solutions: - Multi-leveled page tables

- Inverted page tables

Comparing the 2 levels of hierarchy

° Cache Version	Virtual Memory Version
° Block or Line	Page
° Miss	Page Fault
° Block Size: 32-64B	Page Size: 4K-8KB
° Placement: Direct Mapped, N-way Set Associative	Fully Associative
° Replacement: LRU or Random	Least Recently Used (LRU)
° Write Thru or Back	Write Back

Picking Page Size

° Minimize wasted storage
— small page minimizes internal fragmentation
— small page increases size of page table, TLB usage
° Minimize transfer time
— large pages (multiple disk sectors) amortize disk access cost
— sometimes transfers unnecessary info
— sometimes prefetches useful data
° General trend toward larger pages because
— big cheap RAM
— increasing memory - disk performance gap
— larger processor address spaces