Virtualization





 e.g., process abstraction, virtual memory, cache memory, virtual machine, simultaneous multithreading (SMT),...(the list goes on)

Virtualization Example: Process abstraction



Single physical CPU

Multiple logical CPUs

CPU

CPU

CPU

Virtualization Example: Virtual Memory



DRAM

Two Aspects of Virtualization

Functionality

- Hardware: MMU (memory management unit) and exception mechanism ("page fault")
- Software: virtual memory management routines based on page tables, one for each process, in the operating system (OS)

Performance

- Optimizing regular memory references
 - Temporal locality (locality in time)
 - If an item is referenced, it will tend to be referenced again soon.
 - Spatial locality (locality in space)
 - If an item is referenced, items whose addresses are close by will tend to be referenced soon.
- Optimizing page table references
 - TLB (Translation Look-aside Buffer)

Typical Workload Pattern



Source: Glass & Cao (1997 ACM SIGMETRICS)

Virtualization Example: Cache Memory



SRAM



DRAM



Virtualization Example: Virtual Machine



e.g., VMware, VirtualPC, Connectix Virtual PC