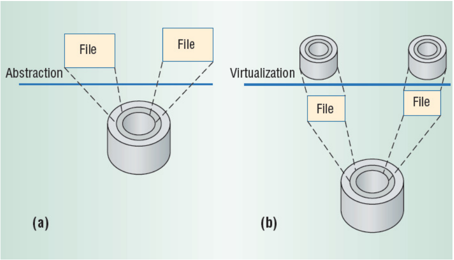
Extended OS

Virtual Machines

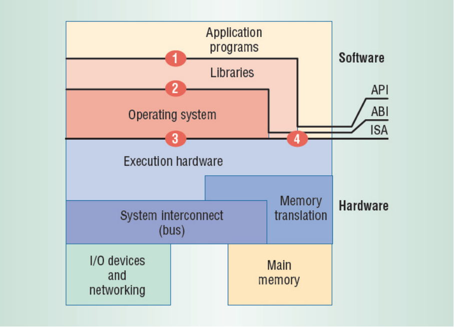
References:

Smith, J.E.; Ravi Nair; , "The architecture of virtual machines," *Computer* , vol.38, no.5, pp. 32- 38, May 2005

Abstraction & Virtualisation

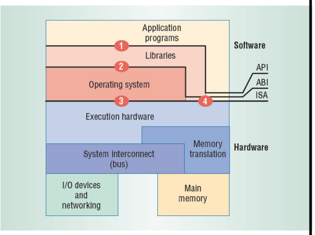


Interface Levels



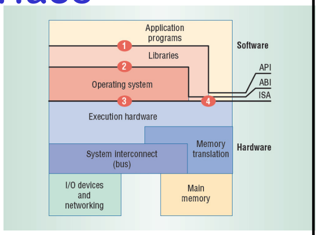
Instruction Set Architecture

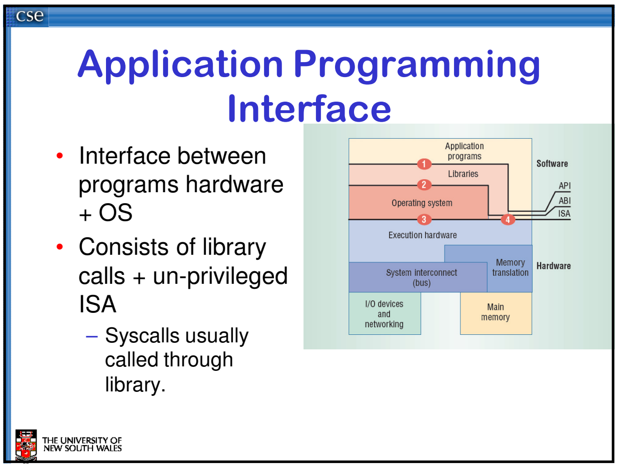
- Interface between software and hardware
- Divided between privileged and un-privileged parts



Application Binary Interface

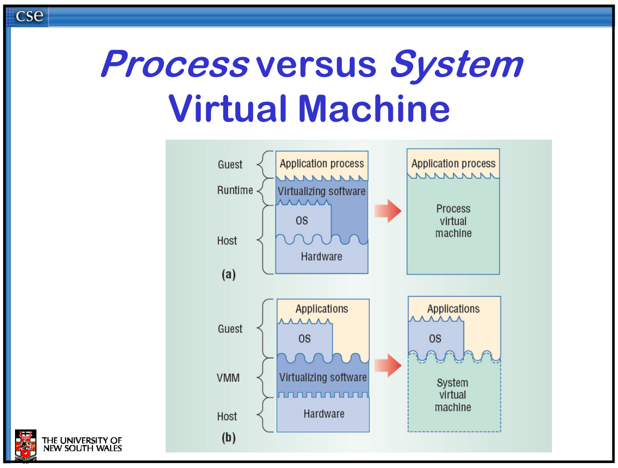
- Interface between programs hardware + OS
- Consists of system call interface + un-privileged ISA



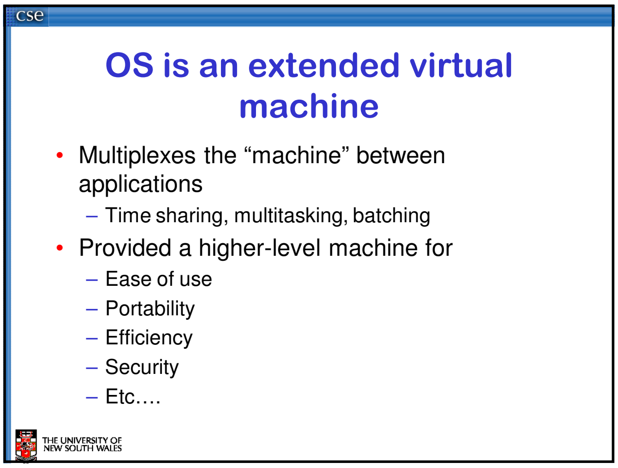


Application Programming Interface

- Interface between programs hardware + OS
- Consists of library calls + un-privileged ISA
  - Syscalls usually called through library.

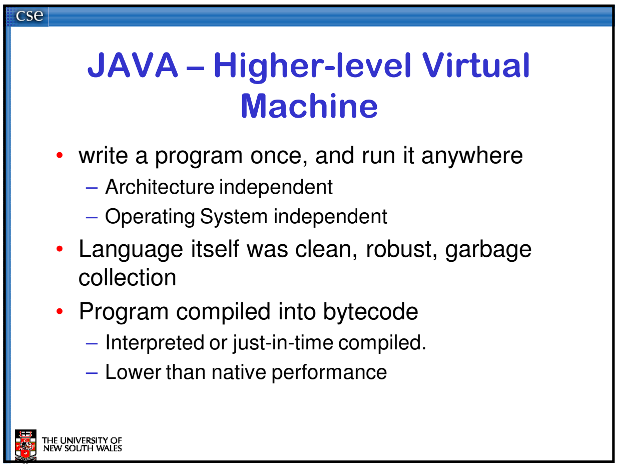


Process versus *System* Virtual Machine



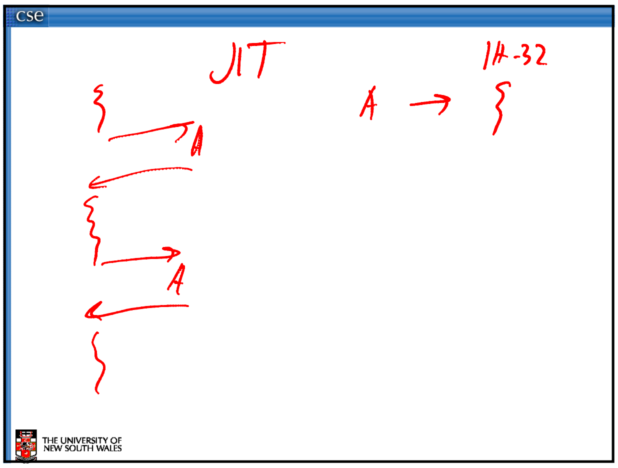
OS is an extended virtual machine

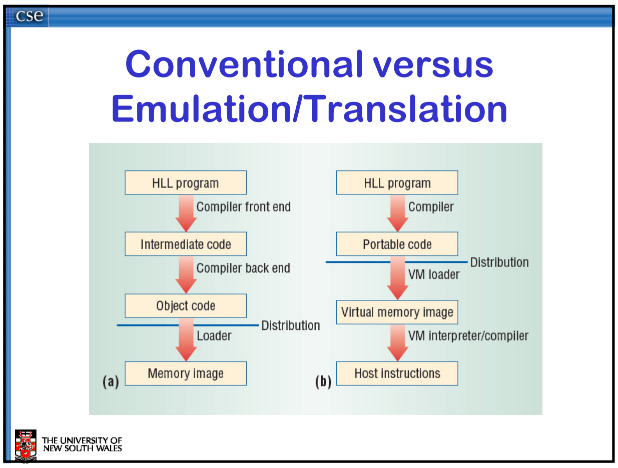
- Multiplexes the “machine” between applications
  - Time sharing, multitasking, batching
- Provided a higher-level machine for
  - Ease of use
  - Portability
  - Efficiency
  - Security
  - Etc….



JAVA – Higher-level Virtual Machine

- write a program once, and run it anywhere
  - Architecture independent
  - Operating System independent
- Language itself was clean, robust, garbage collection
- Program compiled into bytecode
  - Interpreted or just-in-time compiled.
  - Lower than native performance





Conventional versus Emulation/Translation

Issues

- Legacy applications
- No isolation nor resource management between applets
- Security
  - Trust JVM implementation? Trust underlying OS?
- Performance compared to native

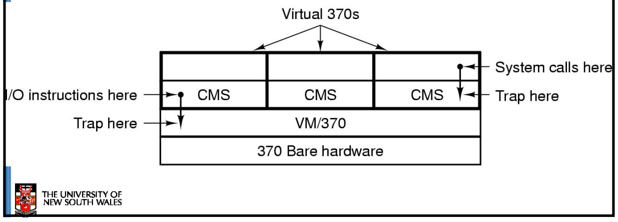
Is the OS the “right” level of extended machine?

- Security
  - Trust the underlying OS?
- Legacy application and OSs
- Resource management of existing systems suitable for all applications?
- What about activities requiring “root” privileges

Virtual Machine Monitors

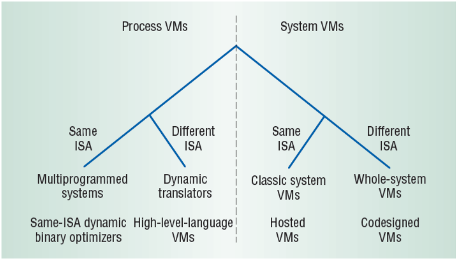
- Provide scheduling and resource management
- Extended “machine” is the actual machine interface.

IBM VM/370



Advantages

- Legacy OSes (and applications)
- Server consolidation
- Concurrent OSes
  - Linux – Windows
  - Primary – Backup
    - High availability
- Test and Development
- Security
  - VMM (hopefully) small and correct
- Performance near bare hardware
  - For some applications



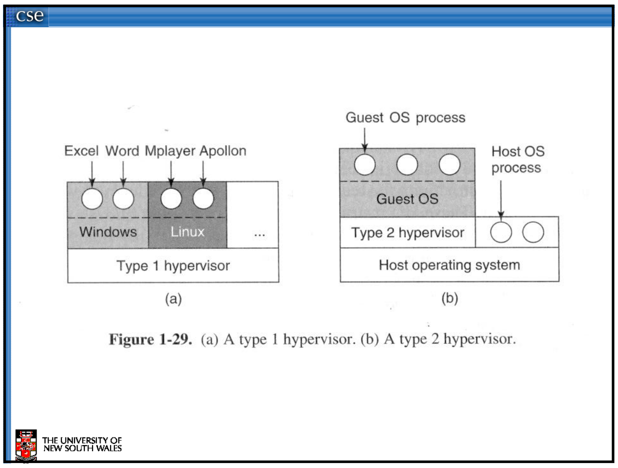
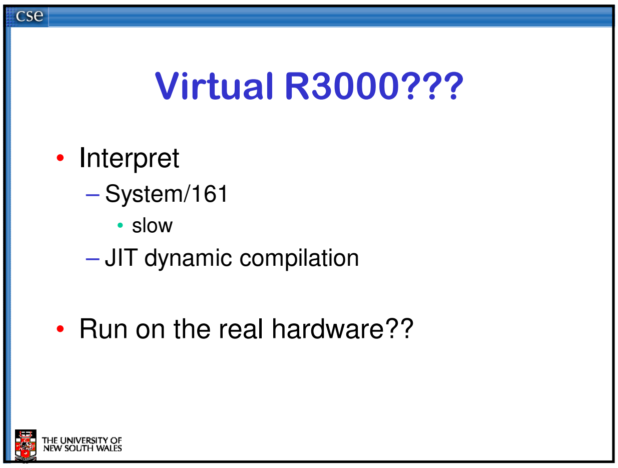


Figure 1-29. (a) A type 1 hypervisor. (b) A type 2 hypervisor.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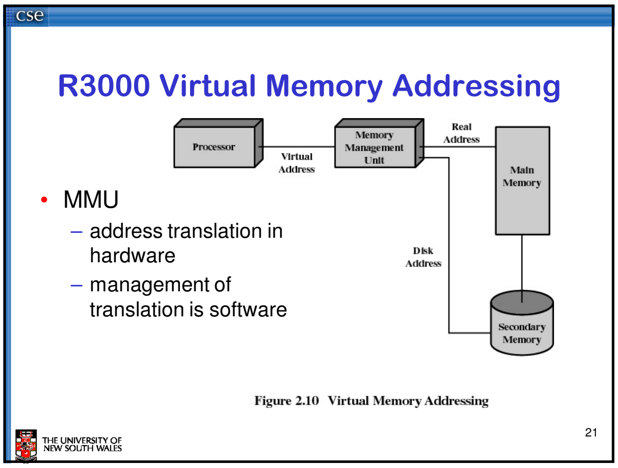
Virtual R3000???

- Interpret
  - System/161
    - slow
  - JIT dynamic compilation
- Run on the real hardware??



R3000 Virtual Memory Addressing

- MMU
  - address translation in hardware
  - management of translation is software

Figure 2.10 Virtual Memory Addressing

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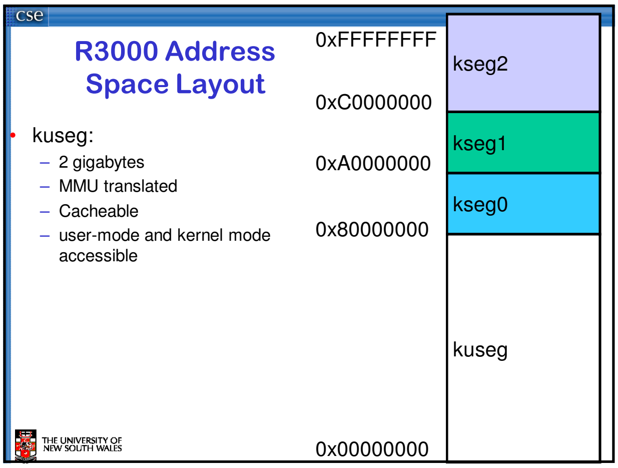
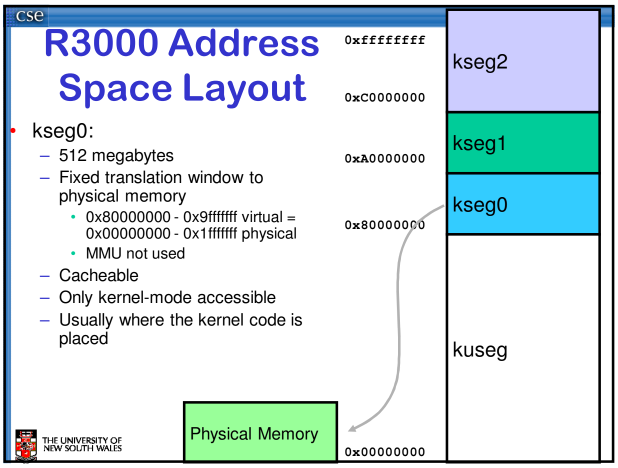


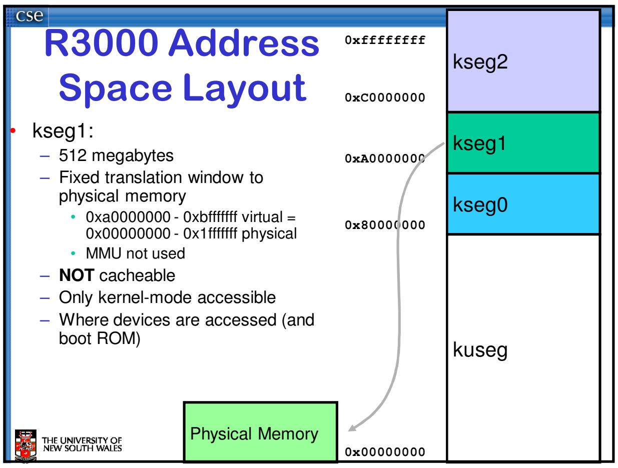
R3000 Address Space Layout

- kuseg:
  - 2 gigabytes
  - MMU translated
  - Cacheable
  - user-mode and kernel mode accessible



R3000 Address Space Layout

- kseg0:
  - 512 megabytes
  - Fixed translation window to physical memory
    - 0x80000000 - 0x9fffffff virtual = 0x00000000 - 0x1fffffff physical
    - MMU not used
  - Cacheable
  - Only kernel-mode accessible
  - Usually where the kernel code is placed

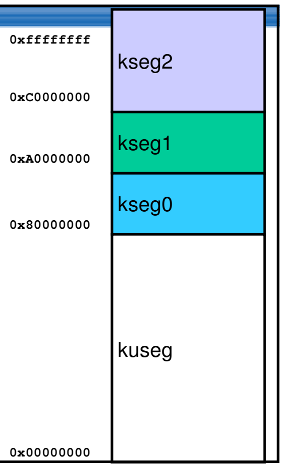


R3000 Address Space Layout

- kseg1:
  - 512 megabytes
  - Fixed translation window to physical memory
    - 0xa0000000 - 0xbfffffff virtual = 0x00000000 - 0x1fffffff physical
    - MMU not used
  - **NOT** cacheable
  - Only kernel-mode accessible
  - Where devices are accessed (and boot ROM)

R3000 Address Space Layout

- kseg2:
  - 1024 megabytes
  - MMU translated
  - Cacheable
  - Only kernel-mode accessible

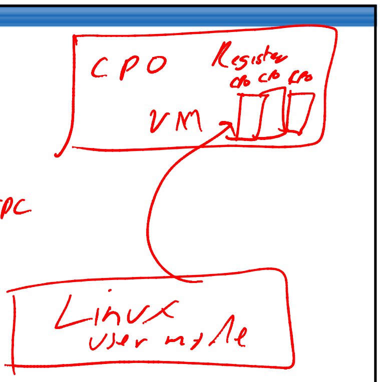


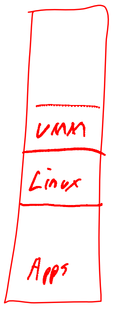
Issues

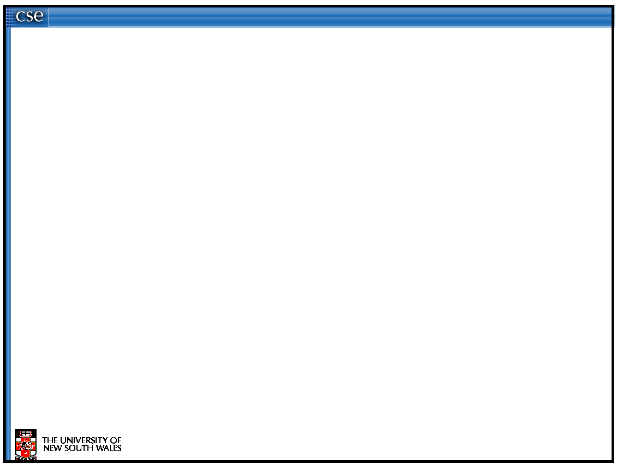
- Privileged registers (CP0)
- Privileged instructions
- Address Spaces
- Exceptions (including syscalls, interrupts)
- Devices

mfc0
mfc0

mfc0 r1, c0_EPC







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