Extended OS

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

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)
- Concurrent OSes
  - Linux – Windows
  - Primary – Backup
- Security
  - VMM (hopefully) small and correct
- Performance near bare hardware
  - For some applications

Virtual R3000???

- Interpret
  - System/16
    - slow
  - JIT dynamic compilation
- Run on the real hardware??

R3000 Virtual Memory Addressing

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

R3000 Translation

Unprivileged (User) Mode

\[ A_{\text{phys}} = \begin{cases} f_{\text{mmu}}(A_{\text{virt}}) & : A_{\text{virt}} < 0x80000000 \end{cases} \]

Privileged (Kernel) Mode

\[
A_{\text{phys}} = \begin{cases} f_{\text{mmu}}(A_{\text{virt}}) & : A_{\text{virt}} < 0x80000000 \\ A_{\text{virt}} - 0x80000000 & : 0x80000000 \leq A_{\text{virt}} < 0x80000000 \\ A_{\text{virt}} - 0x80000000 & : 0x80000000 \leq A_{\text{virt}} < 0x00000000 \end{cases} \]

\[ f_{\text{mmu}}(A_{\text{virt}}) = \begin{cases} A_{\text{virt}} & : A_{\text{virt}} \geq 0x00000000 \end{cases} \]
Issues

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