Virtualization

COMP 252 - Lecture 5

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Learning Objectives

- To describe the aims of virtualization
  – in the context of similar aims in other software components
- To distinguish between **system** and **process** virtualization
- To place **system** and **process** virtualization in the context of other **virtualization technologies**
- To understand how system, process and other virtualization technologies are likely to develop

Additional (optional) Reading

All available on the course materials webpage:
`http://syllabus.cs.manchester.ac.uk/ugt/2017/COMP25212/`

- Barham, P., Dragovic, B., Fraser, K., Hand, S., Harris, T., Ho, A., Neugebauer, R., Pratt, I. and Warfield, A., 2003, October. **Xen and the art of virtualization**. In ACM SIGOPS operating systems review (Vol. 37, No. 5, pp. 164-177). ACM.
- Rosenblum, M. and Garfinkel, T., 2005. **Virtual machine monitors: Current technology and future trends**. Computer, 38(5), pp.39-47.
- Adams, K. and Agesen, O., 2006. **A comparison of software and hardware techniques for x86 virtualization**. ACM SIGARCH Computer Architecture News, 34(5), pp.2-13.

Regarding memory subsystems:

- Drepper, U., 2007. **What every programmer should know about memory**. Red Hat, Inc, 11, p.2007.

Virtualization Technologies

- CPU
- Virtual Memory
- Storage Virtualization
- Virtual Machines (e.g., Java)
- System Virtualization (e.g., VMware, VirtualBox, XEN)

Virtualization Technologies – Objectives

Isolate details of hardware from the software that uses it

- VM: amount of physical memory and layout
- Storage: position, size, and location of virtual disk
- JVM: instruction set encoding, registers, etc
- System: I/O devices, memory, #CPUs

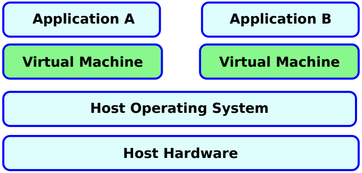
Sounds familiar?

Operating System and Virtualization

- Operating System isolates Application from Hardware
- Operating System still closely integrated with hardware:
    - device drivers, interrupts, #CPUs, disk layout, etc
- Installing OS creates state
- Installing an application within OS creates state
- Moving an installed Application from one system to another is complex
- Moving an installed OS is very complex
- Moving a running application is almost impossible

Process vs. System Virtualization

- Process Virtualization:
    - Run a process under the control of a layer of software
    - e.g. JVM, Rosetta, Pin
- System Virtualization:
    - Run an operating system under the control of a layer of software
    - e.g. VMware, XEN, KVM, etc



Application A

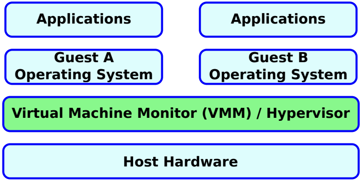
Application B

Virtual Machine

Virtual Machine

Host Operating System

Host Hardware



Applications

Applications

Guest A Operating System

Guest B Operating System

Virtual Machine Monitor (VMM) / Hypervisor

Host Hardware

Taxonomy of Virtualization

Virtualization can:

- Translate between equivalent facilities
  - Instruction Set Architecture? Library? System Calls?
- Change level of abstraction
  - Garbage Collection? Virtual functions?
  - Performance tools? Debugging tools?
- Multiplex/demultiplex resources
  - Hide their physical number or quantity

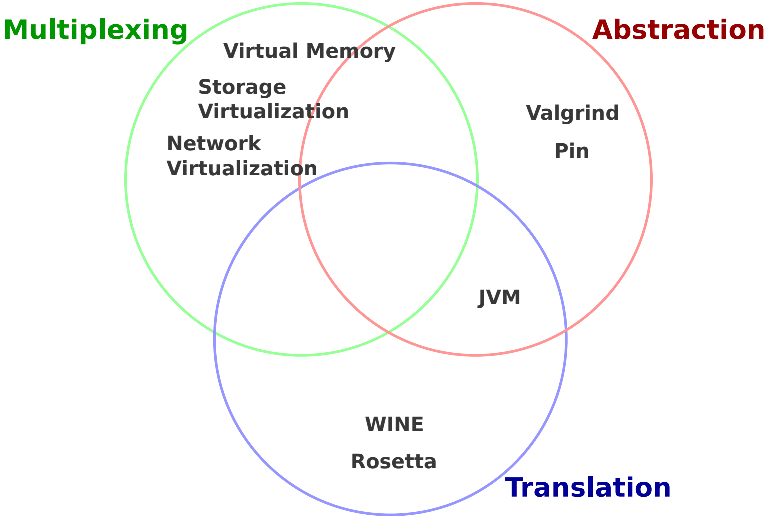
Process Virtualization

- **JVM**
  - Interprets, then compiles “byte code” files
  - “Write once, run anywhere”
  - extensive libraries – extend OS API as Java standard
- **Rosetta**
  - Translates PowerPC binaries “on-the-fly” to x86
  - Maps PPC system calls to x86 (different calling conventions)
  - Calls some native x86 procedures from PPC code

Process Virtualization

- **pin**
  - “annotate” Intel binary (www.pintool.org)
  - run a binary and collect (user-specified data)
- **valgrind**
  - “sandbox” Intel (++) binaries
  - check memory references and dynamic allocation
  - and lots of other analyses

Types of Virtualization



Adoption Model for Virtualization

- Introduce as Transparent Layer
  - Discover performance problems
- Provide Management API
  - Initial focus: performance and manageability
  - Secondary focus: integration facilities
- Provide full User-level API
  - Applications are built or integrated using API