Extra Topics - Virtualization

OPS102 Week 6 Class 1

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Outline

Virtualization and Virtual Machines

Virtualization Platforms

In the Real World

Summary

Virtualization and Virtual Machines

Precursor – Virtual Memory

- Virtual Memory was first implemented in the early 1960's.
- It provides a contiguous memory abstraction for processes.
- System memory is a fixed size (e.g. laptop with 16GB RAM).
- Each process requests RAM for code and storage.
- The OS maps each process's RAM pages (blocks of RAM) to physical pages
  - Anywhere in the physical memory
  - Or perhaps even paged out to disk
  - Programs see a contiguous, easy to deal with, address space.
- This means that RAM can be allocated as needed and programs get simple memory management.
- Virtual RAM allocated to programs is not limited by the amount of physical RAM in the computer.

Big Idea: Abstraction by the OS

- Virtual memory is an example of the OS providing an abstraction.
- The OS gives programs an idealized view of memory, and dealt with managing memory reality.
- Can that idea of abstraction / mapping be applied elsewhere?
- Yes it can.
- Ths OS can provide an abstraction layer to a program.
- What if the program was running an entire, separate OS?

Early Virtual Machines

- IBMs CP/CMS (late 1960's) offered each user their own, single-user machine and operating system.
- CP ran on the real hardware, and ran multiple instances of CMS as user programs.
- Each user had their own dedicated (virtual) computer.
  - With disk, printer, card reader, and card punch.
- These days we would call CP a "hypervisor".
- https://en.wikipedia.org/wiki/Virtual_machine
- VMs became mainstream with the release of VMware Workstation in 1999, and with GSX Server (hosted) and ESX (hostless) in 2001.
- Current processors have hardware virtualization support.

Advantages of Virtualization

- Virtualized servers, especially at scale, have many advantages over "bare-metal" servers.
- Flexibility – quickly create a new machine without needing additional hardware.
- Utilization – need fewer servers and less computing capacity overall, due to shared resources.
  - The same way time-sharing computing for users is more efficient than computer-per-user.
- Migration – VMs can migrate seamlessly across hosts, for easier maintenance and handling of hardware failures.
- Snapshots – Save the state before you experiment, revert on failure
- Export/Import – Save a standard image, share with friends

Virtualization – Why Should You Care?

- These days computing virtualization is everywhere.
    - Cloud computing platforms, VPS (Virtual Private Server) hosting.
    - Enterprise computing systems are largely based on virtual machines.
    - Even our friend matrix? A cluster of virtual machines.
- Being able to instantly (or quickly) create a new computer is a huge advantage when developing or deploying software.
- Virtualization makes it easy for a software developer to develop in their preferred environment (e.g. Windows) and test in another (e.g. Linux).

Virtualization Platforms

Some Virtualization Platforms

- For personal computers:
  - VMware Workstation
  - Parallels – mostly on MacOS
  - VirtualBox – freely available, cross platform
- For servers:
  - VMware ESXi
  - Microsoft Hyper-V
  - XCP-ng – descendant of Xen, XenServer
  - Proxmox

Developing for Other Platforms

- Virtualization can allow you to emulate other platforms on your standard developer system.
- Apple's Xcode environment for IOS development virtualizes iPhones.
- Android Studio (and others) virtualize Android phones.
- QEMU can run virtual machines running other processors e.g. ARM.
- Makes cross-platform development and testing much easier.

Jails, Zones, and Containers

- OS-level virtualization provides isolated user space instances on the same operating system.
  - Allows running software in a restricted environment.
  - Improves security and reliability.
- Originated (I think) with FreeBSD jails, Solaris zones, and Linux LXC containers.
- Nowadays Docker containers are everywhere.
- Almost like lightweight, easily and quickly deployed VMs.
  - Especially when "orchestrated" with tools like Kubernetes.

In the Real World

Real World Example

- Web developers often develop with a local "development image" virtual machine.
- The developer uses their preferred environment and editing tools.
- The devimage VM provides an environment similar to production, serving up the developer's local files on a web server.
- Edit a file, save, immediately available in your browser.

VirtualBox – Let's Give It a Try

- VirtualBox is a popular cross-platform hosted hypervisor.
- Create multiple virtual machines with CPU, GPU, RAM, disk.
- Let's install linux!

Summary

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- Virtualization and Virtual Machines improve effciency and ease-of-use.
- Easier for developers and system administrators.
- Better utilization of overall computing capacity.
  - And when demand is lower, migrate VMs and turn off some hosts.