The Impact of Virtualization on Modern Computing Environments

Mendel Rosenblum
Talk Outline

• The Problem: Computers work poorly
  – Operating Systems get blamed

• Virtualization: A level of indirection
  – Use data center hardware more efficiently
  – Help improve operating systems

• Software distribution and service delivery models
Modern Computer Environments

Apps: Oracle, SAP, Microsoft, ...

OS: Microsoft, Linux, ...
- Manage hardware
- Export better abstractions

Hardware: IBM, HP, Dell, ...
Operating System Market Dynamics

• Chicken & egg problem:
  – Need applications to get users
  – Need users for applications and drivers

• Incentive: Try to be everything to everybody

• Results:
  – Bloated
  – Unreliable
  – Insecure
  – High management cost
  – Barrier to innovation
Problem: Failure to multiplex hardware

- **Common:** One service/user per computer
  - Encoded in best practices
    - Modular design, security, Windows NT
  - More services equals more computers
- **Moore’s law effect:**
  - Cheaper computer
  - More idle time per computer
- **Result:** Highly inefficient computing
Virtualization – A level of indirection

Compatibility and High Performance
Virtualization layer attributes

- Tractable complexity
  - Interface & Implementation
- Strong Isolation
  - High reliability & Security
- Innovation possible
  - The Game
Server Consolidation

Diagram showing server consolidation using hypervisors.
Add Live Virtual Machine Migration
Add Distributed Resource Scheduling

Optimize

- Utilization
- Power
- Service Level Agreements
Data center wide virtualization layer

Same Logical View

Hardware Pool

Virtualization Layer
Treat Hardware as a Pool of Resources
Effect of Virtualization on Data Center

- Much higher hardware utilization
  - Scheduler tries to drive utilization up to 100%
    - Saves much power
  - Dynamic placement is superior to static
- A data center wide distributed system
  - A foothold for innovation
  - What more can we do?

Monitor software
Automatic Restart on failures
Site Disaster Recovery
Add Record/Replay to the virtualization

• Record
  – Input to the virtual machine
  – Asynchronous external events (e.g. interrupts)
• Relatively compact encoding
• Enable logging and replay of execution
Mask Hardware Failures

Virtualization Layer
Discussion

• Compelling for enterprise data centers
  – Less so for HPC and portable devices

• Functionality versus assurance
  – Hopefully we learned from our mistakes

• Software runs the same in VMs
  – Crappy software is still crappy
Virtualization Impact on Software

Virtualization has done a few things:

• Monitor and report software behavior
• Treat VM images as first class objects
  – Version control, etc.
• Some security enhancements
Package Software Deployment

- Procure hardware
- Install operating system
- Install OS patches and remove services
- Install application
- Install application patches
- Apply configuration
Virtual Appliances
Virtual Appliances for software deployment
Virtual Appliances vs. Package Software

• Virtual appliance advantages:
  – No more user assembly
  – Better security

• Virtual appliances issues:
  – Difficult to integrate multiple appliances
  – Heavy weight
  – Different software licensing model
Virtual Appliance Operating System

- Don’t need complex hardware management
- Don’t need broad application support
- Application-specific operating system
- Look at hardware appliance operating systems for examples
OSes for Virtual Appliances

• OS selected by application developer
  – Criteria:
    • Match needs of application
    • Reliability, security, etc.
    • License fees

• Likely features of a virtual appliance OS
  – Highly customizable
  – Support appliance infrastructure

• Opportunity for new OSes
Roles in software service delivery

- Computing Hardware
- Software Development
- Software Configuration
- Management/maintenance
- Users
Two Extremes: Package Software & SaaS

• **Package Software**
  – Example: Windows + Exchange + Outlook
  – Users does all except software development

• **Software as a Service (SaaS)**
  – Example: Gmail
  – All roles (hardware, software, management) except users done by service provider

• Virtualization lets us access other points in the space
Cloud Computing with Virtualization

For user, model supports different:
- Virtual Appliance builder
- Virtual Appliance maintainer
- Execution platform

Local Data Center

Cloud Data Center
Virtualization and Cloud Computing

- **Key advantage of leveraging existing software**
  - Compatible migration vs. new paradigm
  - Can existing package software convert to a service?
- **Hardware virtualization vs. PaaS**
  - Advantage: Ultimate software flexibility, Strong isolation
  - Disadvantage: Need infrastructure, Weight
Summary

Level of indirection trick still works
   More manageable, more available, more reliable, more secure, ...

New options for software services
   Not just better hardware management