Implementation of Hypervisor in UEFI Firmware

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Agenda

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• Background
• Virtual UEFI (vUEFI) and Virtual ACPI (vACPI)
• Firmware Implementation
• Firmware for Cloud Computing
• Sample usage model
Introduction and motivation
1. As the number of CPU increases the complexity of OS/Hypervisor increases dramatically.
2. Container provided an alternative solution for hypervisor, but it have security issues.
3. We can implement hardware assisted virtualization layer in firmware; generate multiple virtual BIOS interfaces for operating systems which host containers
Virtualization Background
Typical Virtualization Architecture
A virtual machine (VM) is a software implementation of a machine (i.e. a computer) that executes programs like a physical machine.

The goal of vBIOS is to be able to allocate resources to build virtual machine such that the user can install an OS with vUEFI interface and the OS can configure and use the virtual hardware with vACPI.

By introduce standards, we try to separate data and control panel.
Virtual UEFI (vUEFI) and Virtual ACPI (vACPI)
Virtual UEFI

- Based on customer defined profile, VMM allocate resources for vBIOS
- Specify Initial Power On CPU
- Define virtual memory instead of detecting physical memory
- Connect to virtual network and storage device
- Current UEFI specification can basically meet these requirements. An open source project OVMF from Tianocore.org provides
  - Libraries and drivers related to virtual machines
  - An entire firmware implementation with supports UEFI on open source virtual machines.
Device Manager in Guest Window OS
Virtual ACPI

- ACPI specification was originally proposed by Microsoft and owned by a small group of companies such that only limited virtualization information is available through Intel, Microsoft and HP.
- ACPI has been widely adopted by the IT industry. In October 2013, the governance of ACPI has been changed and the specification is now managed by UEFI Forum.
- In addition to Windows, many other Operating Systems and Hypervisors are now supporting ACPI and vACPI.
ACPI described virtual hardware hierarchy

• Instead of describe real hardware we need vACPI to describe customer virtual hardware.

• For PCI devices supporting SR-IOV, we should use VF instead of PF.

• For multiple CPU architecture, we would like to see ACPI provides CPU topology information such that guest OS can control the CPU directly assuming the virtual machine only using CPU partition.
ACPI Power States

• S3
  – May not be able to put the CPU in power saving mode if the physical CPU is shared by multiple VMs. But we can avoid this problem if we use CPU partition. It is useful for migration

• S4
  – Good for quick boot

• C states: exit virtual processor from scheduler and wake back

• P states: voltage ignored, but frequency will affect scheduler

• D states: device control method can be encapsulated within ACPI AML code.
Firmware Implementation
Virtual Machine Challenges

When VM need to go through the hardware emulation layer and cause performance deterioration.

Because of the shared VMM layer, one VM might be attacked by other VM. The worst case is that VMM itself being attacked.

If we can avoid enter VMM during VM operation, we should be able to solve both performance and security problem.
Process to run an application

Customer VM requirement

Present VM with virtual hardware and control interface

vACPI Virtual Hardware

VMM allocate resources to build VM

vACPI Virtual Hardware

Build vUEFI boot interface

vUEFI Virtual Hardware

Install guest OS

After OS Installed, vUEFI services are stopped

vACPI Virtual Hardware

Install Application

Application

vACPI Virtual Hardware

vACPI is integrated and controlled by OS

OS

vUEFI Virtual Hardware

OS

vACPI
Industry solutions for Virtualization

• Hardware assisted virtualization
  – Intel VT-X
  – Intel VT-d
  – Intel VT-C
• Trusted Computing
  – IBM vTPM
• Standards
  – SR-IOV
  – MR-IOV
Industry efforts to improve performance (PCI-SIG)
Various choice to build a VM with 4 CPUs
VM Migration

• Emulated device
• Para virtualized
• Physical
  – Build VM with additional hardware resources
  – Using existing Server RAS features such as hot plug, error reporting, etc to facility migration
Hot Plug

- ACPI
  - Well defined and exposed to OS
- PCI-SIG
  - SHPC – Standard Hot plug Controller-complicated
- Vendor Specific not good for various OS
Firmware for Cloud Computing
- Cloud BIOS
Accelerator Virtualization

Accelerator is used on task intensive purpose. There is little meaning to have virtual accelerator. Instead we can realize accelerator virtualization through hot plug and migration.
Virtualization without Hypervisor

- vBIOS is used to install OS
- vACPI pass virtual hardware hierarchy and control methods to OS
- Guest OS operates through hardware or firmware assisted virtualization
Sample usage model
Combine multi processor to provide high performance

Benefits and advantages
1. Save hypervisor software cost and make the product more competitive
2. Product can be flexibly arranged based on usage cases
3. Physical partition and hardware assisted virtualization increase reliability, availability and security
4. Bare metal, avoid performance penalty.
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For more information on the UEFI Forum and UEFI Specifications, visit http://www.uefi.org

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