KVM tuning and testing, and SMP enhancement

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Throughout this presentation:
VT-x *refers to Intel® VT for IA-32 and Intel® 64*
VT-i *refers to the Intel® VT for IA-64, and*
VT-d *refers to Intel® VT for Directed I/O*

Agenda

- Performance tuning
- Kernel interrupt controller status
- SMP support
- Testing

Back to KVM-18

- Kernel build performance was only 1/3 of Xen
  - We suspected shadow page table may not be optimized
- We used oprofile to analyze the overhead
  - Anthony & Avi started looking at performance issues at same time

Top 5 findings from oprofile

- Guest only get ~25% cycles
- Excessive MSR save/restore
  - Such as SYSCALL_MASK, LSTAR, CSTAR, KERNEL_GS_BASE, EFER, and K6_STAR
  - load_msrs costs ~7%
  - save_msrs costs ~3.7%
  - kvm_vmx_return costs ~6.1%
    - Hardware VM Exit does save/load for some of the MSRs
- vmx_vcpu_run costs ~3.2%
  - Most time is spent in HOST_FS/GS_BASE write and fx save/restore

Light-weight vs. heavy-weight VM Exit

- A light-weight VM Exit is handled in KVM and returned to guest directly, without host context switch
  - Mostly for shadow page fault
  - Cover 93% of all VM Exits in KVM-18
- A heavy-weight VM exit involves host context switch or transition to Qemu
  - Such as I/O or when signal is pending
  - Require save/restore of MSRs

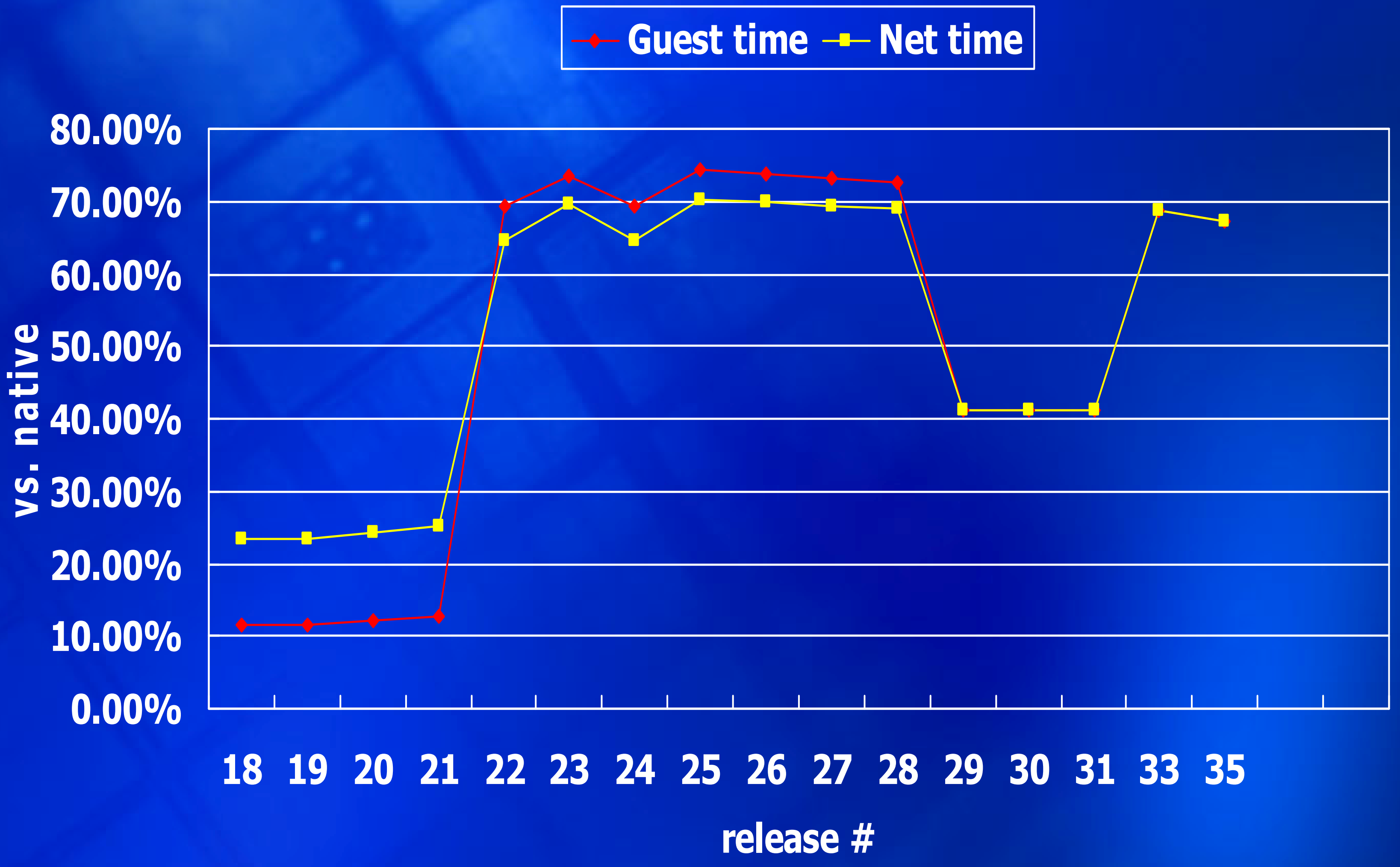
Reduce VM Exits

- Improve shadow page table code
  - Combine guest PTE update with shadow PTE update (Avi Kivity, Qumranet)
  - Increase shadow page table size (Avi Kivity, Qumranet)
- Misc.
  - Port 0x80 access goes to hardware directly (Qing He, Intel)

Shorten VM Exit handling

- Provide quick path for light-weight VM Exit
  - Minimize context save/restore for light-weight VM Exit (Eddie Dong, Intel)
  - Avoid hardware MSR save/restore (Eddie Dong, Intel)
  - Lazy MSR_EFER save/restore (Eddie Dong, Intel)
- Fine tune heavy-weight VM Exit path to save/restore necessary context only
  - Lazy FP (Anthony Liguori, IBM)
  - Some MSRs are not changed in certain environment (Anthony, Avi and etc.)
  - Unbundle fs from gs reload for better SMP support (Laurent Vivier, Bull)

Kernel Build



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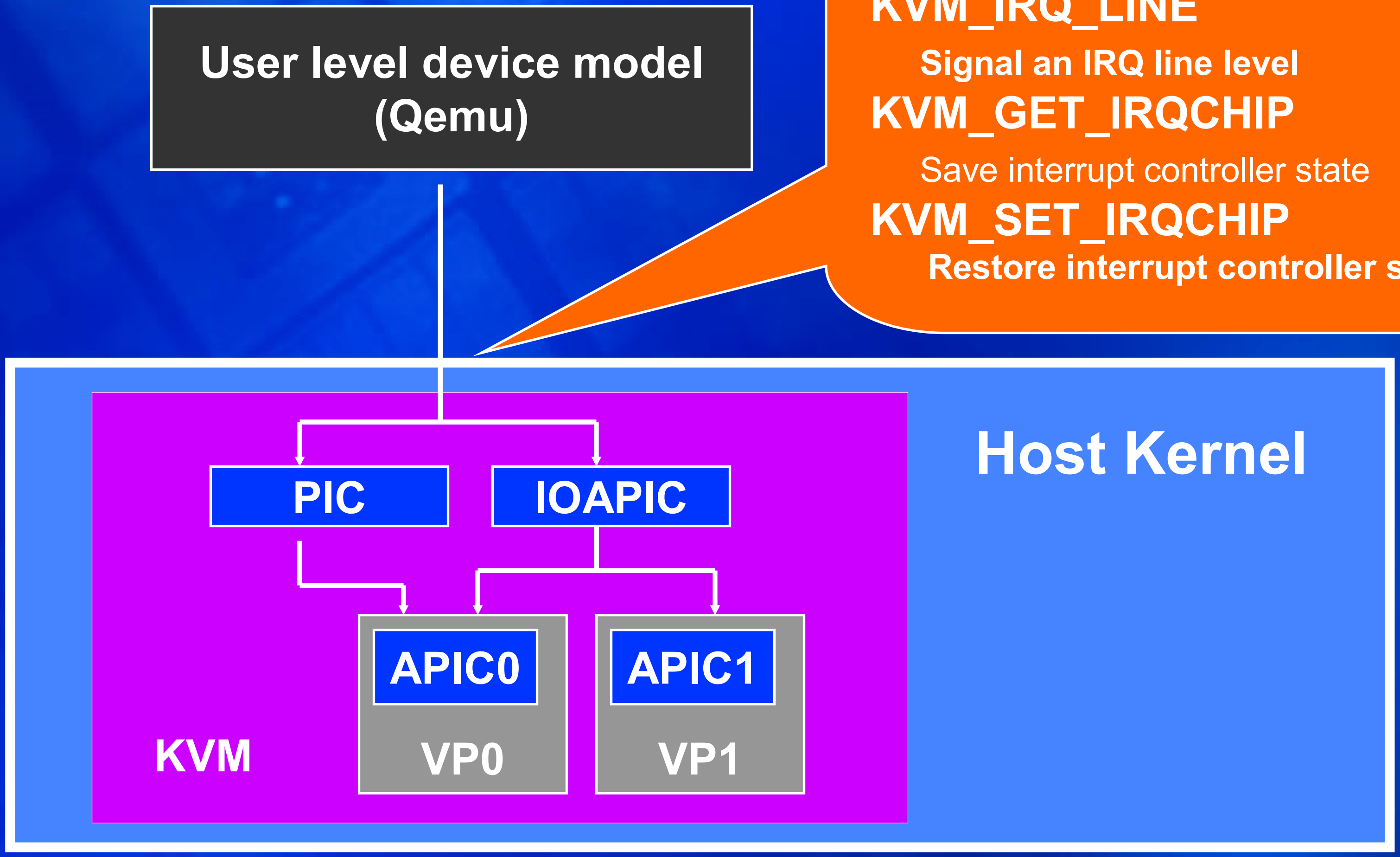
Where to virtualize interrupt controller ?

- User level
  - Pro: Can reuse Qemu device model
  - Con: Performance concern for kernel devices
- Mixed mode (APIC in kernel, PIC/IOAPIC in user level initially)
  - Pros
    - Flexible code structure
    - Better SMP support
  - Cons
    - Complexity
    - Performance concern if IOAPIC is in user level
- Kernel level (lapic5 branch)
  - Pro: Better SMP support, better performance
  - Con: Kernel is subject to device model failure

Kernel interrupt controller I/Fs



KVM_IRQ_LINE

Signal an IRQ line level

KVM_GET_IRQCHIP

Save interrupt controller state

KVM_SET_IRQCHIP

Restore interrupt controller state

Convert vector based VCPU ops to gsi based VM ops

Lapic5 status

- Current Status
  - PIC/IOAPIC/APIC are implemented
  - Live migration is supported
  - SMP Windows/Linux works
- TODO
  - Merge with master branch
  - Stabilize
  - Guest MSI

Lapic5 Quality Status

🟩	Pass
🟧	Can boot, but has issues
🟥	Fail
⬜	N/A

Guest OS	Guest/Host			
	32/32p	32p/32p	32p/64	64/64
Linux 2.6.9 UP	🟩	🟩	🟩	🟩
Linux 2.6.9 SMP	🟩	🟩	🟩	🟩
Linux 2.6.18 UP	🟩	🟩	🟩	🟩
Linux 2.6.18 SMP	🟩	🟩	🟩	🟩
Linux 2.6.22 UP	🟧	🟧	🟧	🟧
Linux 2.6.22 SMP	🟧	🟧	🟧	🟧
Win2k3 R2 No-ACPI HAL	🟩	🟩	🟩	⬜
Win2k3 R2 UP ACPI HAL	🟩	🟩	🟩	🟩
Win2k3 R2 MP ACPI HAL	🟩	🟩	🟩	🟩
Win2k Srv No-ACPI HAL	🟩	🟩	🟩	⬜
Win2k Srv UP ACPI HAL	🟧	🟧	🟧	⬜
Win2k Srv MP ACPI HAL	🟧	🟧	🟧	⬜
WinXP No-ACPI HAL	🟩	🟩	🟩	⬜
WinXP UP ACPI HAL	🟩	🟩	🟩	🟩
Vista UP ACPI HAL	⬜	🟥	🟥	🟥
Vista SMP ACPI HAL	⬜	🟥	🟥	🟥

Lapic5 has same functionality with master branch

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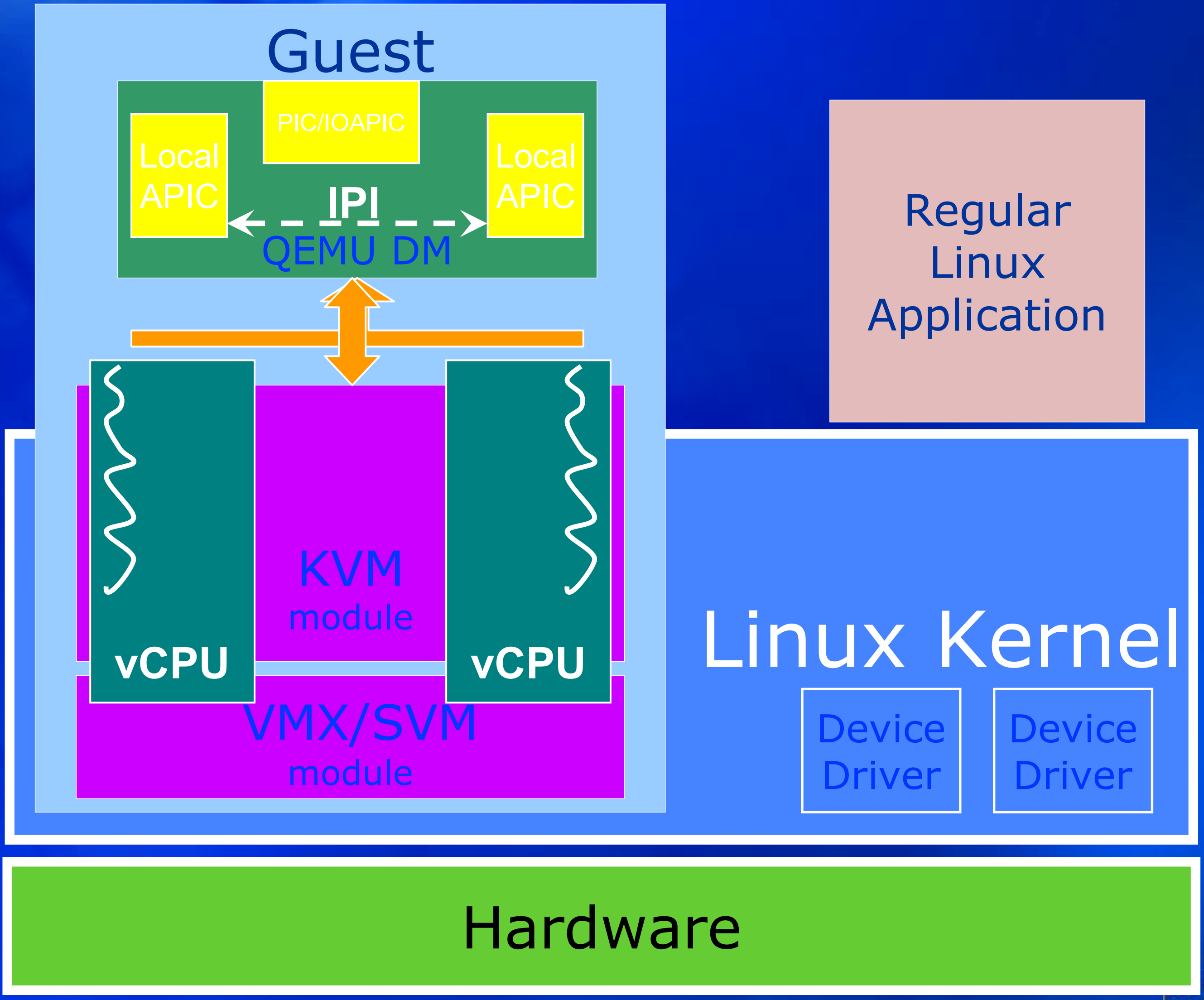
KVM SMP development

- Originally enabled in June based on Greg’s in kernel APIC V09 (Xin Li, Intel)
  - Each vCPU has a dedicated thread
- User level SMP is enabled in KVM-29 (Avi Kivity, Qumranet)
- In kernel interrupt controller (lapic5 branch) based SMP is enabled (Xin Li, Intel)

KVM SMP


Guest
PIC/IOAPIC
Local APIC
Local APIC
IPI
QEMU DM
KVM module
vCPU
vCPU
VMX/SVM module
Regular Linux Application
Linux Kernel
Device Driver
Device Driver
Hardware

KVM SMP

- N model: each vCPU has a dedicated thread
  - Global lock to DM
    - May use device locks instead
  - Each vCPU thread need to handle signals
    - Asynchronous events may be delivered to any thread
- N+1 Model: to add a dedicated thread to handle asynchronous events
  - Such as DMA/AIO
  - Simplify vCPU thread logic

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KVM Test

Goals

- Ensure KVM works well on all Intel Platforms
  - functionality and performance

Activities

- Test KVM master branch daily
- Report issues and regressions ASAP
- Track issues and help community developers to fix issues
- Develop test cases for new KVM features

KVM Test Suites

Test Suite	Test Scope
VM Management	Create/destroy different guest configurations (memory, #VCPU, ACPI, 32/64), Save & Restore, Live Migration etc.
Device Model	Disk, NIC, VGA, Timer, Keyboard, Mouse
Guest OS	LTP, kernel parameters, Windows (HCT,DTM), Guest OS installation (RHEL5, FC6, RHEL4U3, SLES10, OpenSuse10, SLES9, Windows XP/2k/2k3/Vista)
Regression tests	Specific tests for previous failures
Stress	Linux: LTP stress, Crashme, misc workloads Windows: HCT Stress
Performance	Linux: CPU2K, Kernel build, Lmbench, Iometer, SpecJBB, Sysbench, Byte, NetPerf Windows: Sysmark, CPU2k, SpecJBB, PCmark
Nightly Test	Basic test cases for KVM main features, like Save/Restore, SMP Windows/Linux, live migration, and basic virtual devices

Test Frequency

🟩	Daily
⬜	Monthly
🟨	On demand

Guest/Host	32/32p	32p/32p	32/64	32p/64	64/64
Nightly Test	🟩	🟩	🟩	🟩	🟩
Device Model	⬜	⬜	⬜	⬜	⬜
Regression	⬜	⬜	⬜	⬜	⬜
Guest/Guest Installation	⬜	⬜	⬜	⬜	⬜
Performance	🟨	⬜	🟨	🟨	⬜
Stress	🟨	🟨	🟨	🟨	⬜

Test Infrastructure

- Common interface for easy test case development
- Run tests according to predefined configuration and scenario
- Can handle host hang/crash/reboot situations
- Automatic report generation
  - Outputs a journal file in a standard well-defined format

Sample Test Result

```
Issue list
========================================================
1. Could not create kvm guest with memory >=2040

Details
========================================================
PAE:
1. boot guest with 256M memory                      PASS
2. boot two windows xp guest                        PASS
…
IA32e:
1. boot 4 32-bits guest in parallel                PASS
2. boot 4 64-bits guest in parallel                 FAIL
…
Test Log
```

Current Status

🟩	Pass
🟧	Can boot, but has issues
🟥	Fail
⬜	N/A

Guest OS	Guest/Host			
	32/32p	32p/32p	32p/64	64/64
Linux 2.6.9 UP	🟩	🟩	🟩	🟩
Linux 2.6.9 SMP	🟩	🟩	🟩	🟩
Linux 2.6.18 UP	🟩	🟩	🟩	🟩
Linux 2.6.18 SMP	🟩	🟩	🟩	🟩
Linux 2.6.22 UP	🟧	🟧	🟧	🟧
Linux 2.6.22 SMP	🟧	🟧	🟧	🟧
Win2k3 R2 No-ACPI HAL	🟩	🟩	🟩	⬜
Win2k3 R2 UP ACPI HAL	🟩	🟩	🟩	🟩
Win2k3 R2 MP ACPI HAL	🟩	🟩	🟩	🟩
Win2k Srv No-ACPI HAL	🟩	🟩	🟩	⬜
Win2k Srv UP ACPI HAL	🟧	🟧	🟧	⬜
Win2k Srv MP ACPI HAL	🟧	🟧	🟧	⬜
WinXP No-ACPI HAL	🟩	🟩	🟩	⬜
WinXP UP ACPI HAL	🟩	🟩	🟩	🟩
Vista UP ACPI HAL	⬜	🟥	🟥	🟥
Vista SMP ACPI HAL	⬜	🟥	🟥	🟥

We need your help

- **Use Bug Tracker instead of email to track issues**
  - submit issue
  - assign owner
  - update bug status
- **Give us feedback on our test and its results**
- **What more can we do for KVM?**

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