

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

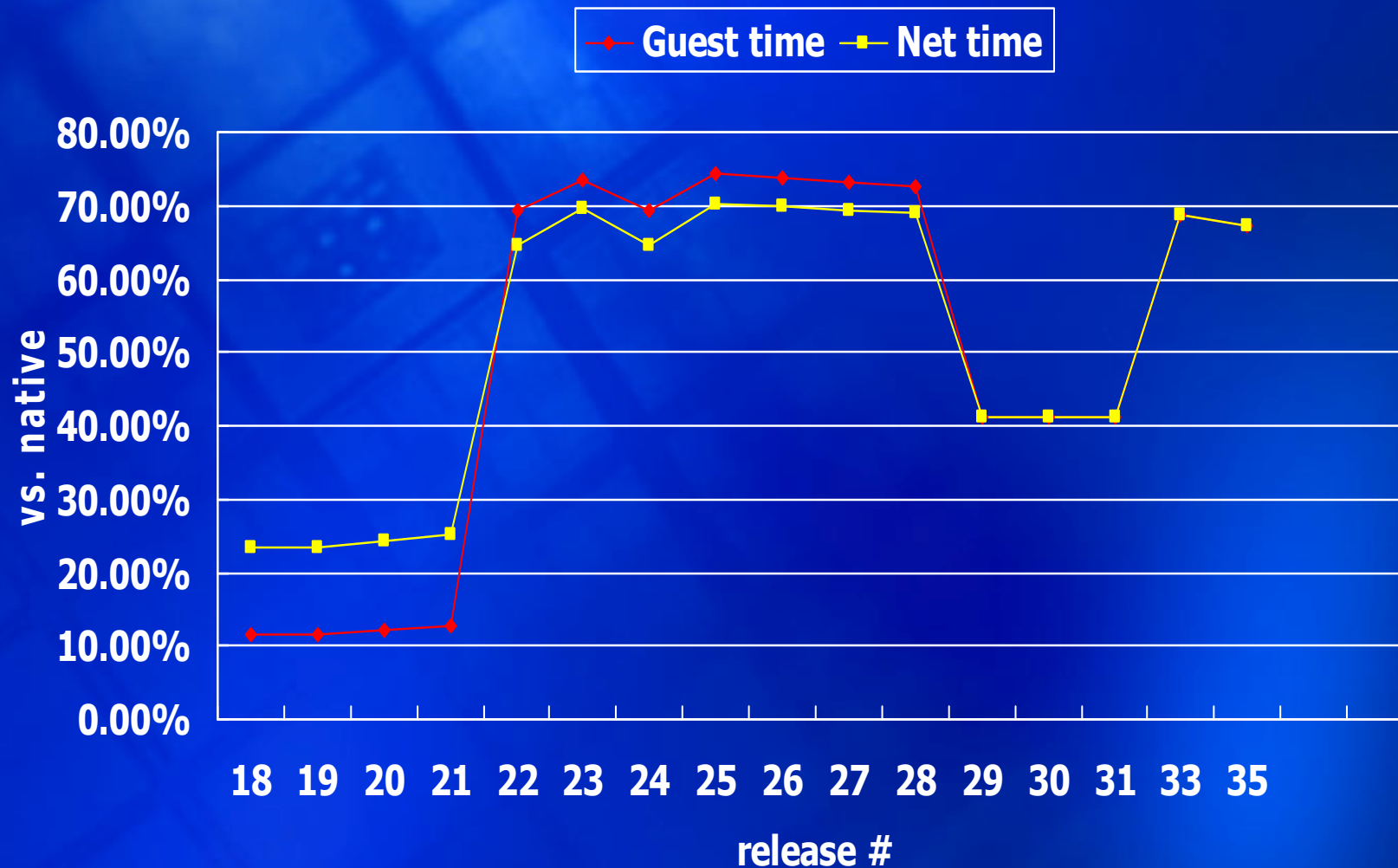
Reduce VM Exits

- **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

User level device model
(Qemu)

KVM_IRQ_LINE

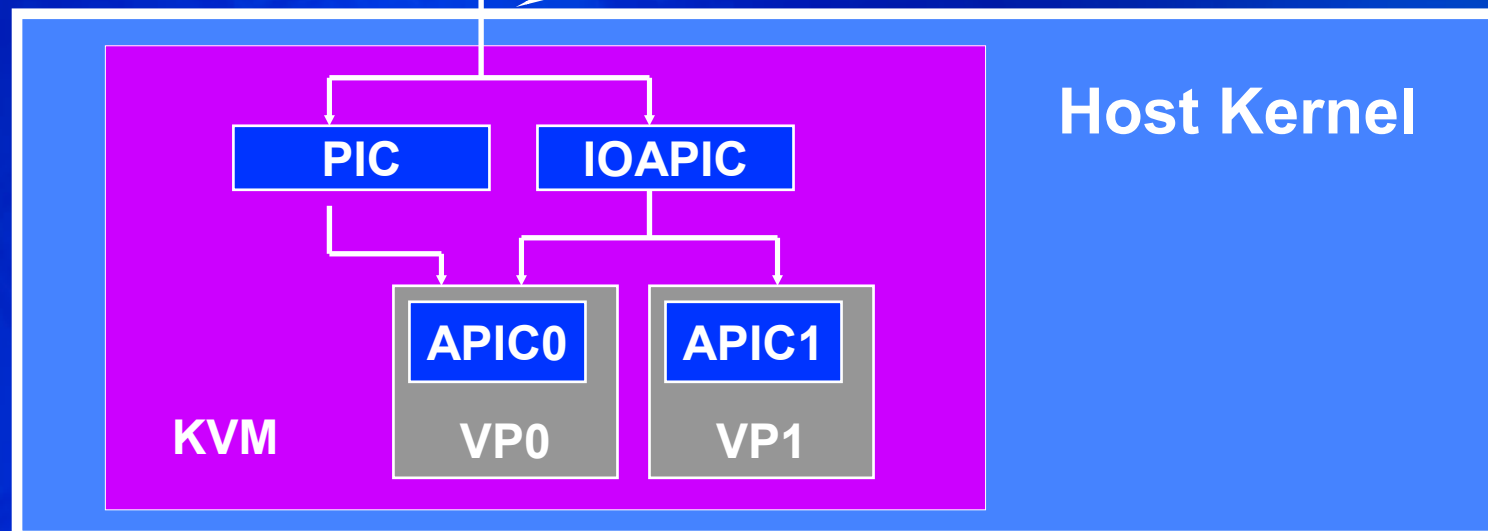
Signal an IRQ line level

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



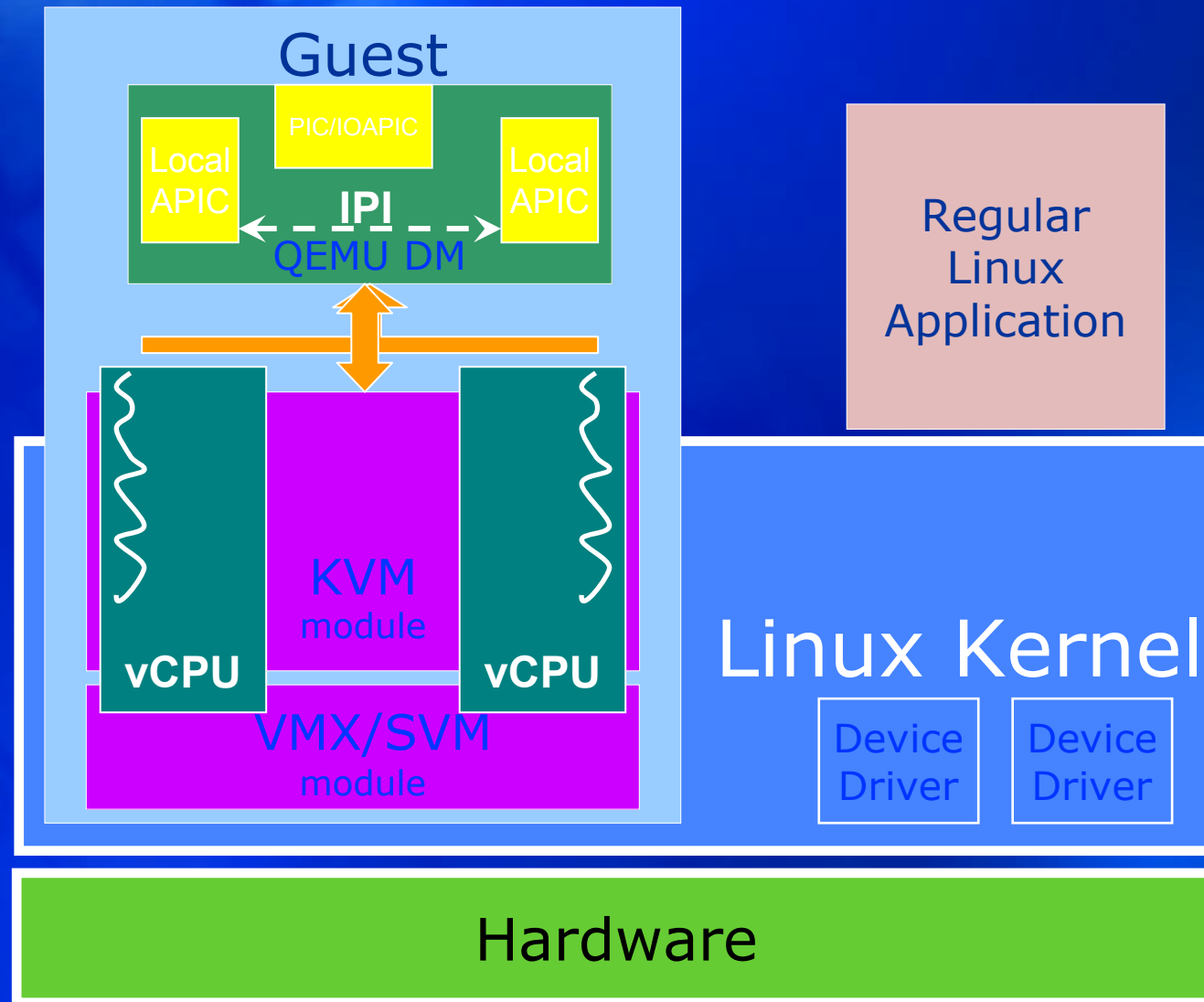
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- **SMP support**
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KVM SMP development

- 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



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				
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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?**

