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Performance Optimization on Huawei Public and Private Cloud

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Agenda

- Optimization for LHP
- Balance scheduling
- RTC optimization

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LHP (Lock Holder Preemption)

- More obvious in virtualization
  - vCPU scheduling
  - Task preemption
- Then
  - Potentially blocking the progress of other vCPUs waiting to acquire the same lock
  - Increasing synchronization latency
  - Performance degradation

LHP (Lock Holder Preemption)

- How to solve or alleviate?
  - PLE (Pause Loop Exiting)
  - DLHS (Delay LH scheduling)
  - Co-scheduling
  - Balance scheduling

PLE

- Hardware support
  - VMCS configuration
- Optimization for Lock Waiters
  - VM Exit actively
  - Avoid waste vCPU cycles for invalid spin
- Pros.
  - Supported by upstream
- Cons.
  - Setting appropriate values of ple_gap and ple_windows is difficult
    - Workloads adjustment
  - Find an appropriate vcpu to yield

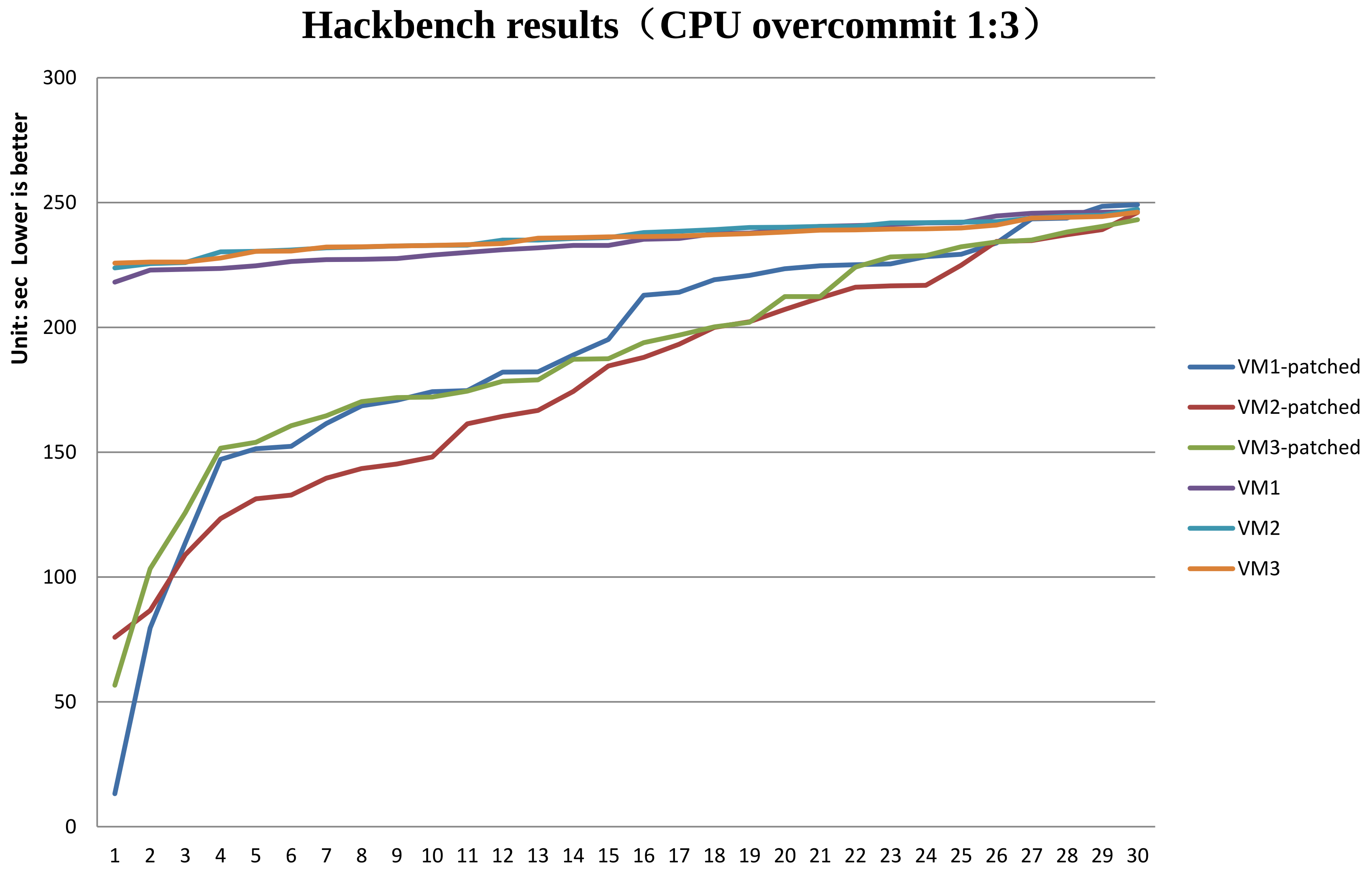
DLHS (Delay Lock Holder Scheduling)

- Background & precondition
  - Usually, lock holders are under interrupt disable contexts
  - Normally, the period of holding lock is shortly
  - Hardware support (e.g. intel VT-X)
    - interrupt window exiting
  - Software support
    - Hrtimer, …

DLHS (Delay Lock Holder Scheduling)

- Solution
  - Set a grace period for LH before scheduling
  - If one vCPU is LH
    - Start one hrtimer, and
    - Set interrupt window exiting for VMCS
    - If the hrtimer expire
      - Clear interrupt window
      - Continue to schedule for vCPU
  - Judge the vCPU release the lock
    - PLE happened
    - Interrupt window exiting happen
    - then
      - Cancel hrtimer
      - Release grace period
      - Schedule the vCPU immediately

DLHS – performance



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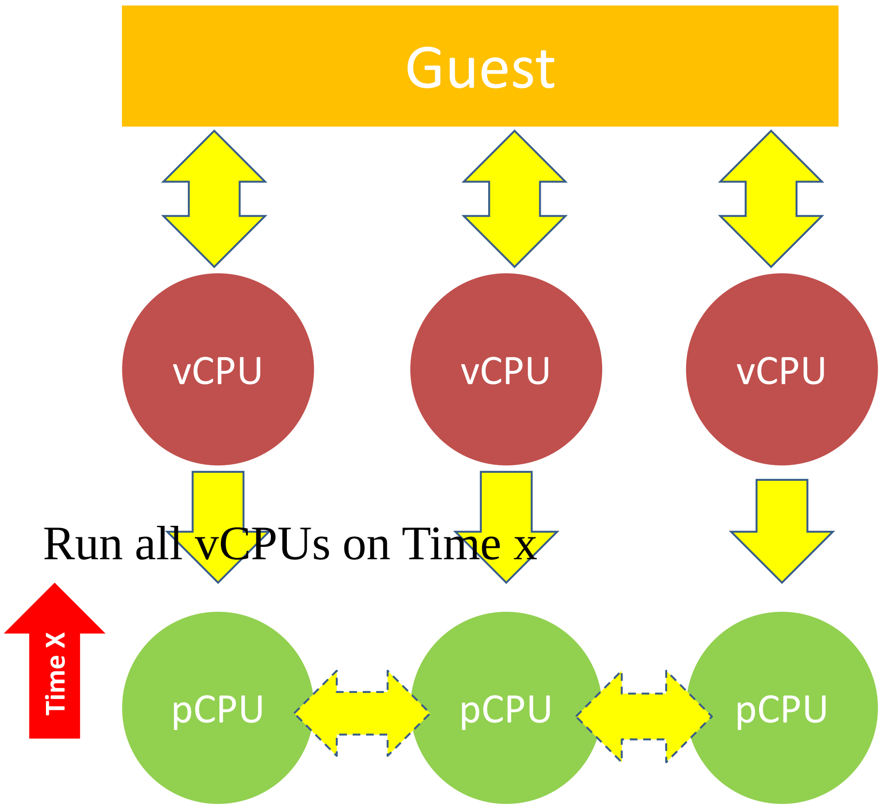
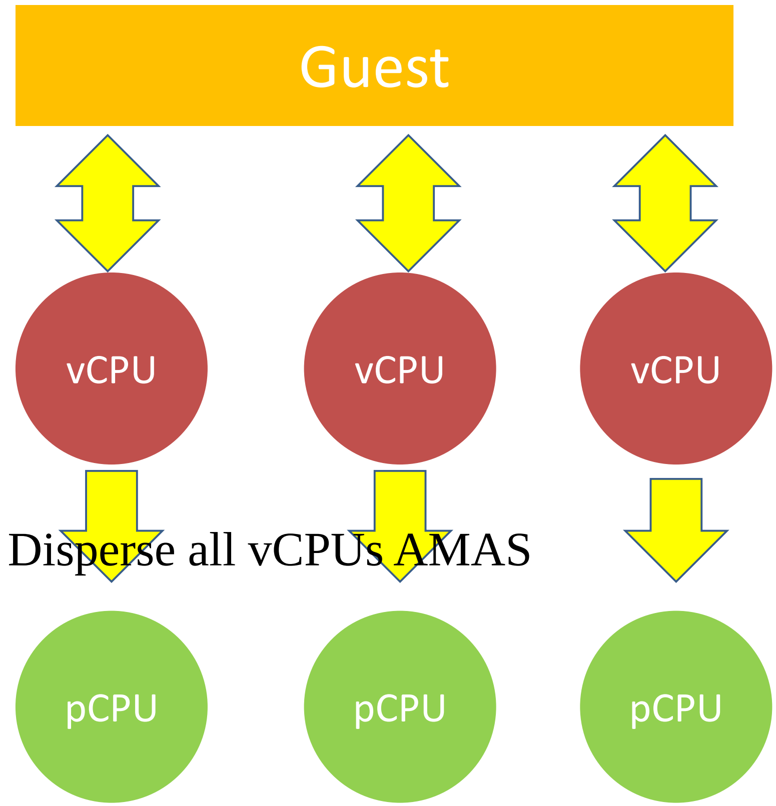
Co-scheduling & Balance scheduling



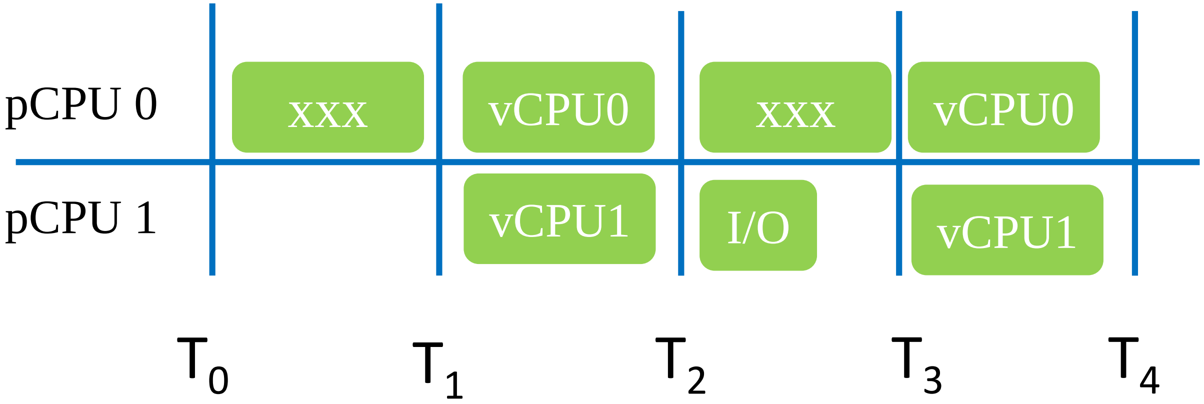
Co-scheduling



Balance-scheduling

Co-scheduling

- CPU fragmentation
  - Reduces CPU utilization
  - Delay vCPU execution
- Priority inversion
  - Degrades I/O performance

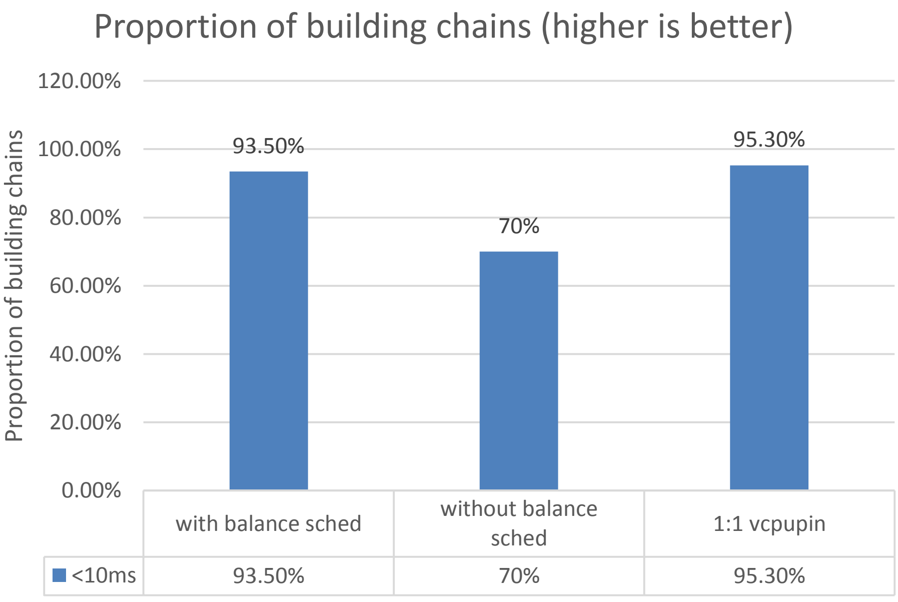


Balance scheduling

- Balances vCPU siblings on pCPUs
  - without precisely scheduling the vCPUs simultaneously
- How to?
  - Uses a bitmap to record all used pCPUs for VM
  - Scheduler adjustment
    - Enqueue & dequeue
    - Migration/find_idle_cpu/select_task_rq etc.

Performance evaluation

- Workload:
  - Pushserver in Huawei Private Cloud
  - Continuous testing for 24 hours
- Results



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RTC on KVM

- Windows use RTC as clock event device
- RTC emulation in Qemu, three timers
  - rtc_periodic_timer
    - Generates periodic interrupts
    - Programmable to occur according to interrupt rate
  - rtc_update_timer
    - Generates alarm interrupts
    - Occur one per second to once per day
  - rtc_coalesced_timer
    - Generates compensation interrupts
    - Slews the lost ticks since different reasons
    - Getting worse and worse with the VM density increase
- Pain points
  - Some operations need to hold BQL
  - Context switching between user space and kernel space
  - Interrupt injecting from user space
  - Performance degradation
    - Latency increase
    - Windows guest density decrease

RTC optimizations on KVM

- Minimize influence of BQL
  - Placing RTC memory region outside BQL
- Using irqfd inject interrupts
- Hyperv features
  - hyperv clock, …
  - Decreases read/write ioports
- Decreases ioport access on 0x70/0x71
- Move RTC emulation to hypervisor
  - Inject interrupts in KVM
  - Reduce context switching
  - But
    - Large attack surface
    - Incompatible with new features, such as split irqchip
- Optimize RTC compensation solution

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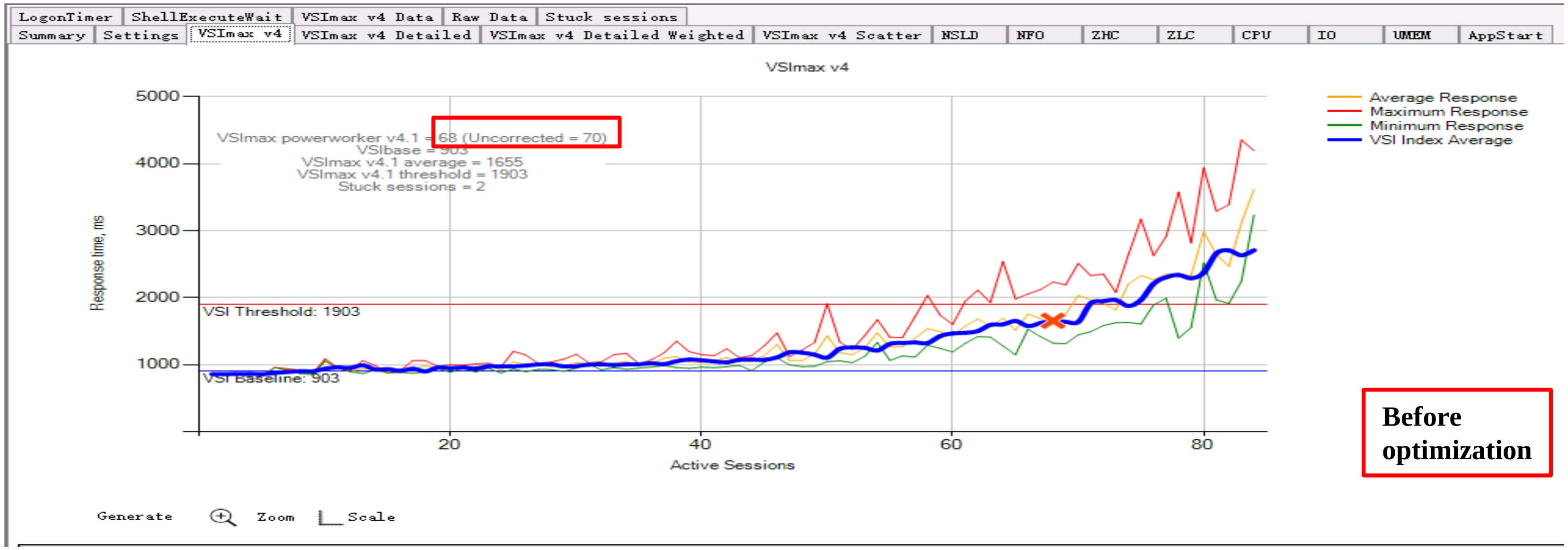
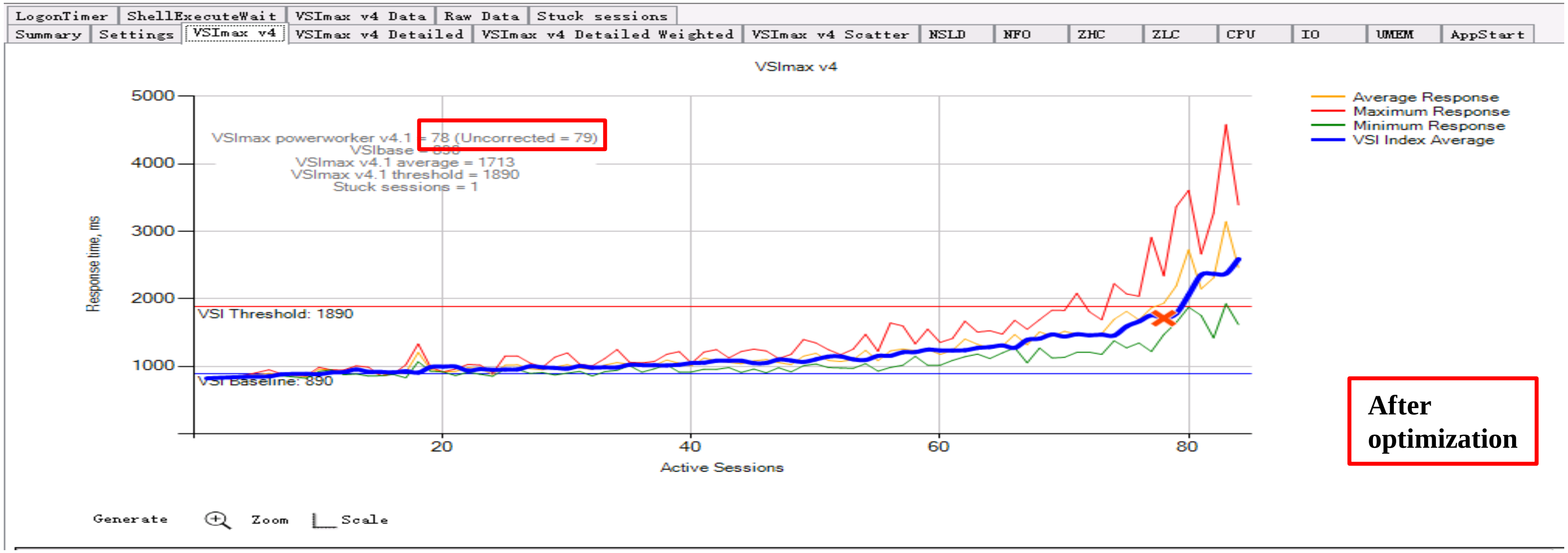
RTC compensation solution

- Slew RTC ticks in hypervisor directly
- Count the coalesced interrupts
  - When an RTC interrupt injecting failed
  - Adjust the count when RTC interrupt rate changes
- Inject coalesced interrupts after EOI handler if exist
  - Don’t need a separate timer
  - More timely
  - Throttle the speed if there is too many coalesced interrupts
- Live migration support
  - Save the coalesced interrupts in src side
  - Restore them in dest side
  - Both KVM and Qemu need to be patched

Optimization evaluation



Before optimization



After optimization

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Thank You!