# Low-Latency KVM Hypervisor

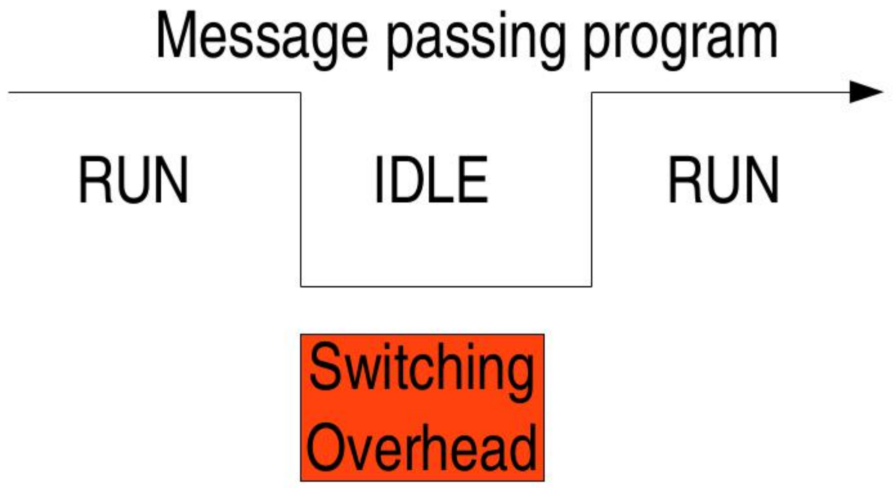
Wanpeng Li
wanpeng.li@hotmail.com

# Agenda

- Adaptive halt-polling
  - – Background
  - – Halt-polling
  - – Adaptive polling for guest halt
- VMX Preemption timer

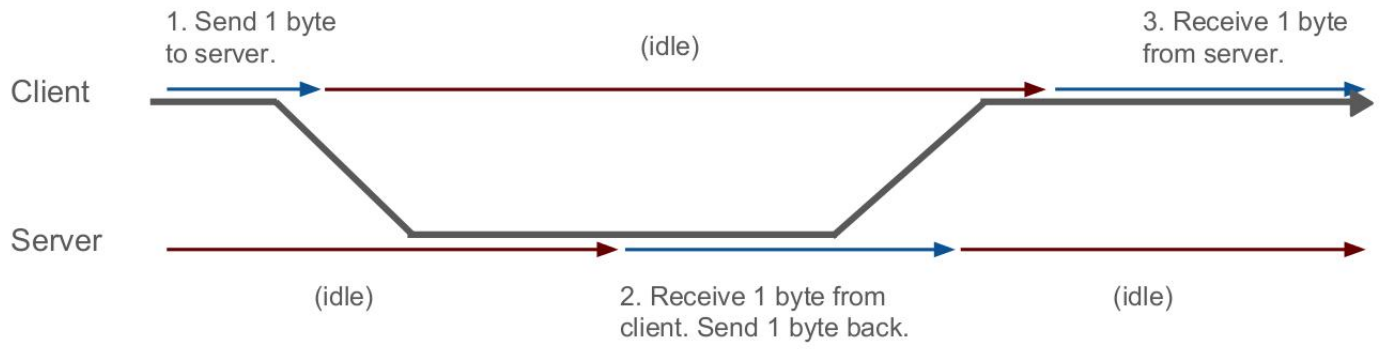
# Message passing workloads

- Usually, anything that frequently switches between running and idle
- Event-driven workloads
  - LAMP servers
  - Memcache
  - Redis
  - SAP HANA
- Inter-process communication
  - TCP_RR (benchmark)



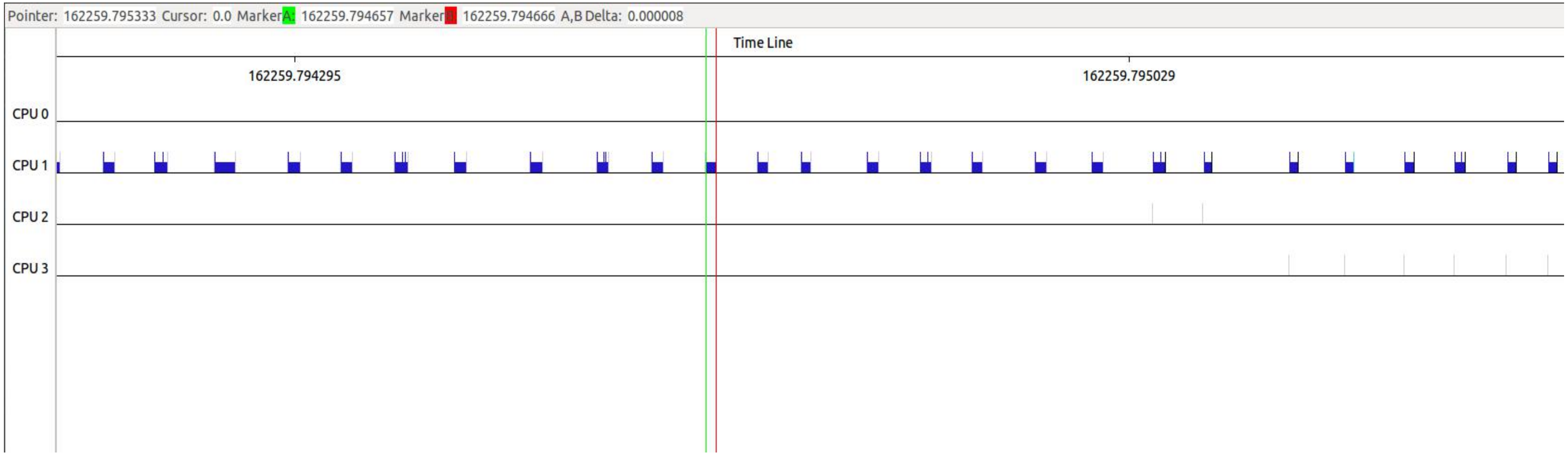
# Message passing workloads

- Microbenchmark: Netperf TCP_RR
  - Client and Server ping-pong 1-byte of data over an established TCP connection
  - Performance: Latency of each transaction
- One transaction:


1. Send 1 byte to server.
(idle)
3. Receive 1 byte from server.
Client
Server
(idle)
2. Receive 1 byte from client. Send 1 byte back.
(idle)

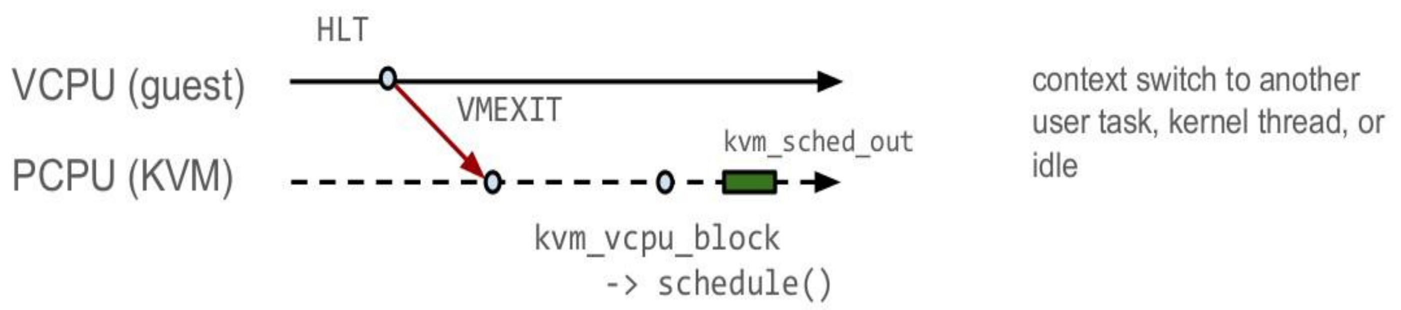
# Message passing workloads

- Frequent transitions between running and idle, spends little time processing each message


Pointer: 162259.795333 Cursor: 0.0 MarkerA: 162259.794657 MarkerB: 162259.794666 A,B Delta: 0.000008
Time Line
162259.794295
162259.795029
CPU 0
CPU 1
CPU 2
CPU 3

# HLT

- HLT
  - x86 instruction, CPU stops executing instructions until an interrupt, debug exception etc arrive
- How it works in KVM
  - Place vCPU thread on a wait queue
  - Yield the CPU to another task
- The overhead
  - around 8500 cycles between later kvm_vcpu_kick and kvm_sched_in



## Never schedule!

- defeat the purpose of CPU overcommit in cloud companies
- some cloud management program will monitor pCPU usage and do the load balance, never schedule just make it mess

## Halt-Polling

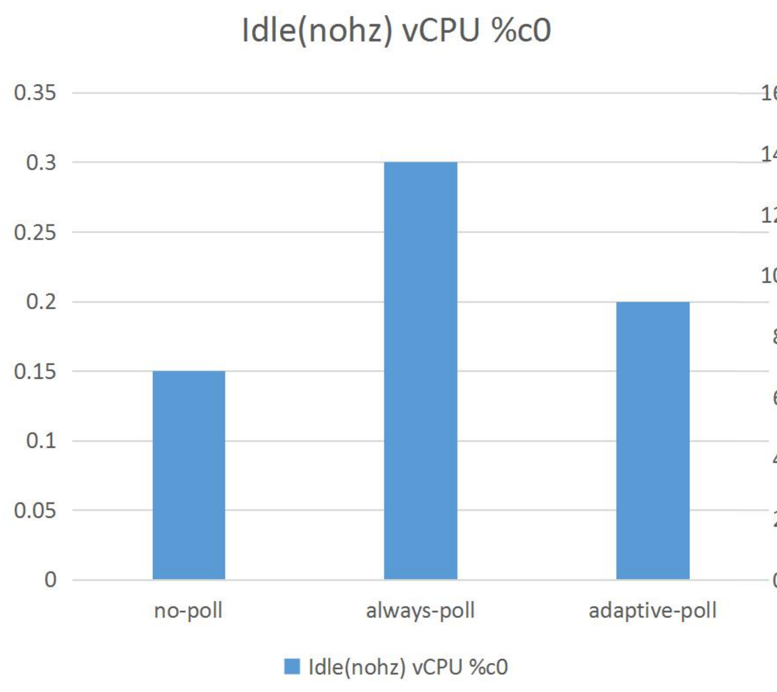
- Step 1: Poll
  - For up to halt_poll_ns nanoseconds:
    - If a task is waiting to run on our CPU, go to Step 2
    - Check if a guest interrupt arrived. If so, we are done.
    - Repeat
- Step 2: schedule()
  - Schedule out until it's time to come out of HLT.
- Pros:
  - Works on short HLTs (< halt_poll_ns ns)
  - vCPUs continue to not block the progress of other threads
- Cons:
  - Increases CPU usage (14% for each idle pCPU(windows guests) if halt_poll_ns = 500,000ns)

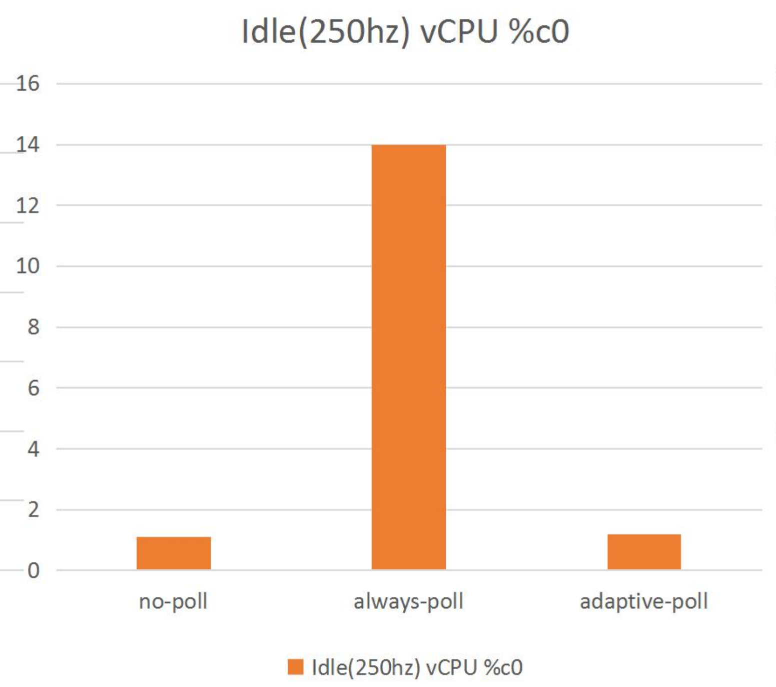
# Adaptive polling for guest halt

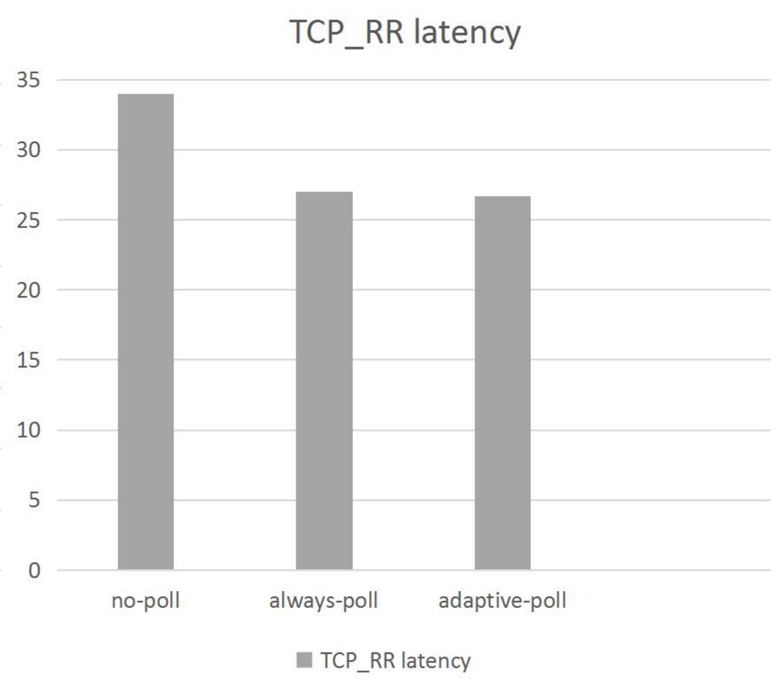
- Step 3: adaptive polling
  - The poll duration can be adaptively shrink/grow according to the history behavior
    - grow halt_poll_ns progressively when short halt is detected (we can get benefit from the polling)
    - shrink halt_poll_ns aggressively when long halt is detected (we can't get benefit from the pollling)

## Adaptive polling for guest halt(Cont.)

- Performance data

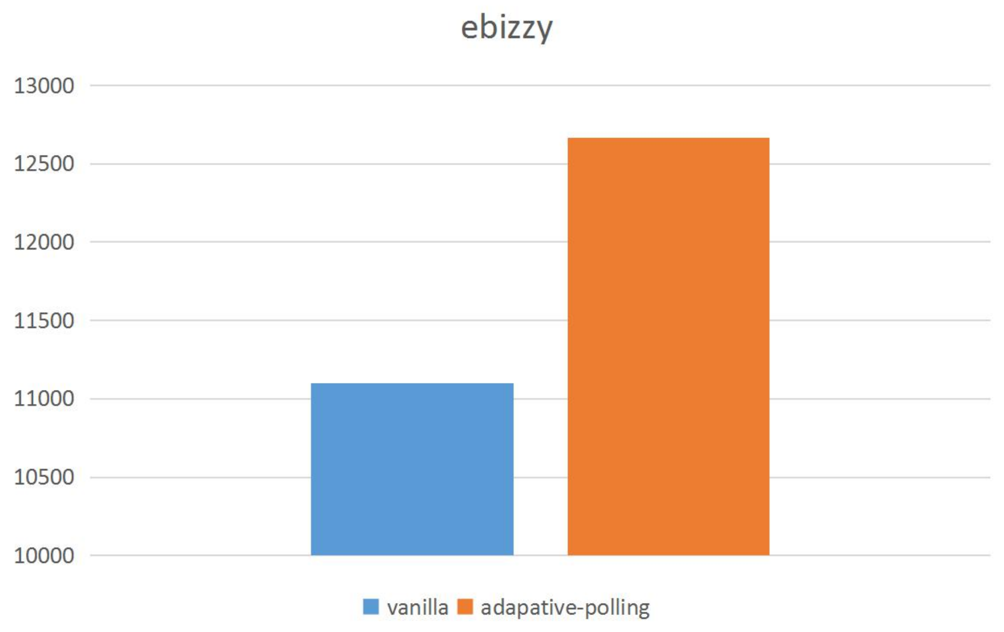


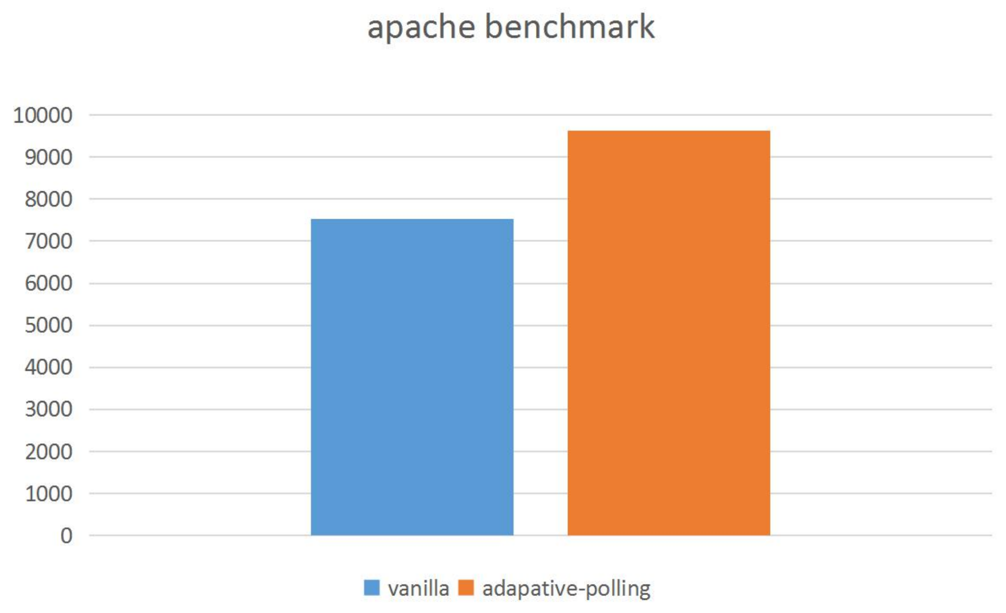




# Adaptive polling for guest halt(Cont.)

- Performance data



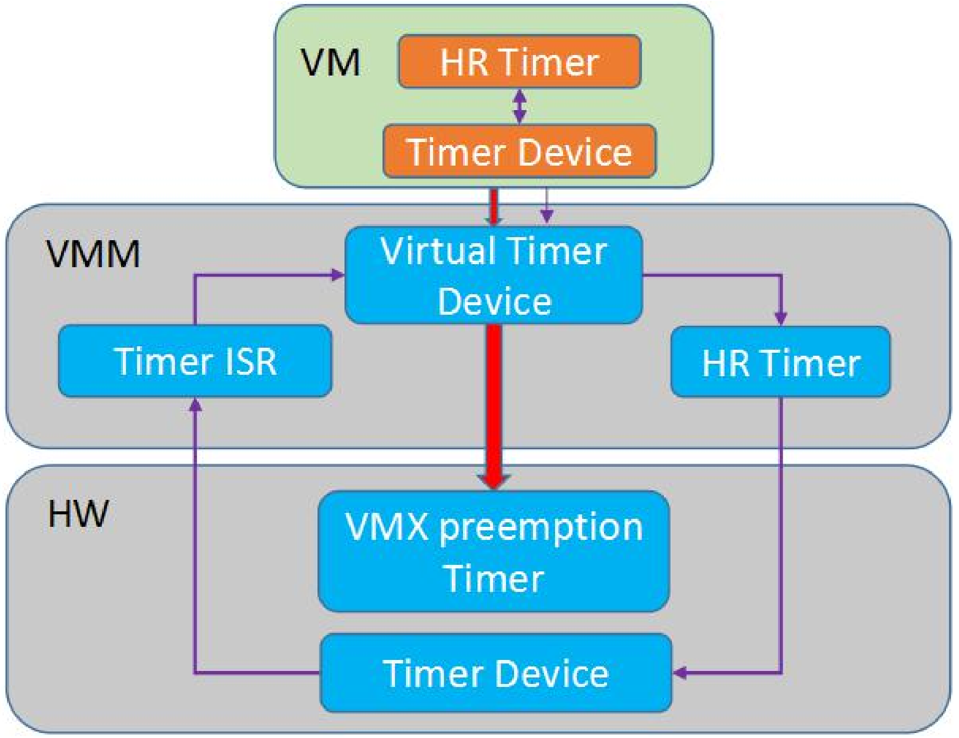


## Adaptive polling for guest halt(Cont.)

- As the polling nature, some cloud companies will configure to their preferred balance of cpu usage and performance, and other cloud companies for their NFV scenarios which are more sensitive to latency are vCPU and pCPU 1:1 pin.

# VMX Preemption timer

- VMX preemption will count down in VMX non-root mode and VM-exit when it reaches zero
- It reduces the cost of:
  - hrtimer cost
  - timer interrupt ISR
  - vm-exit/entry

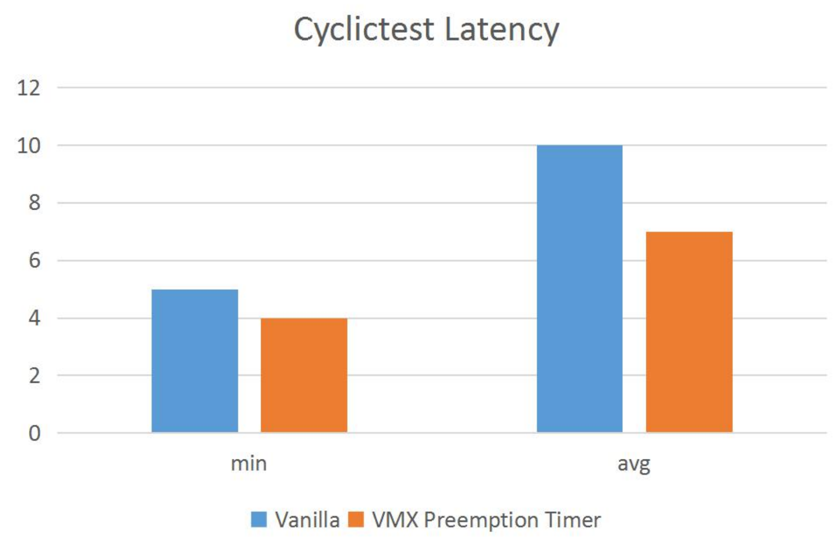


## VMX Preemption timer(Cont.)

- The hrtimer_start/hrtimer_cancel depends on the current hrtimer situation.
- The timer interrupt ISR has far more cost than VMExit handling.
- In system w/o PI, a pair of vm-exit/entry can be caused by the host timer interrupt.
- Both of LAPIC timer tsc deadline mode and periodic/oneshot mode can utilize VMX Preemption timer currently.

# VMX Preemption timer(Cont.)

- Performance data



## Reference

- David matlack, Message Passing Workloads in KVM
- https://lkml.org/lkml/2015/9/3/615
- https://www.spinics.net/lists/kvm/msg134057.html
- https://lkml.org/lkml/2016/10/24/219

Q/A?