Performance Monitoring for KVM Guests

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Agenda

Problem statement

Choices

Issues

Status

Future directions

Problem statement

Allow users of virtual machines to identify sources of performance problems in their guests

Types of performance problems

- Algorithmic
- Networking
- Storage
- Cache/TLB use
- SMP / NUMA
- Language runtime
- Scheduling
- Problems induced by the virtualization layer

Performance Monitoring Unit (PMU)

- Hardware component integrated into modern CPU cores
- Counts and reports architectural events
  - Clock cycles, instructions retired, cache misses...
- Counts and reports micro-architectural events
  - MEM_LOAD_UOPS_RETIRED.HIT_LFB: Retired load uops which data sources were load uops missed L1 but hit FB due to preceding miss to the same cache line with data not ready
- Tools read these counter and correlate with source code

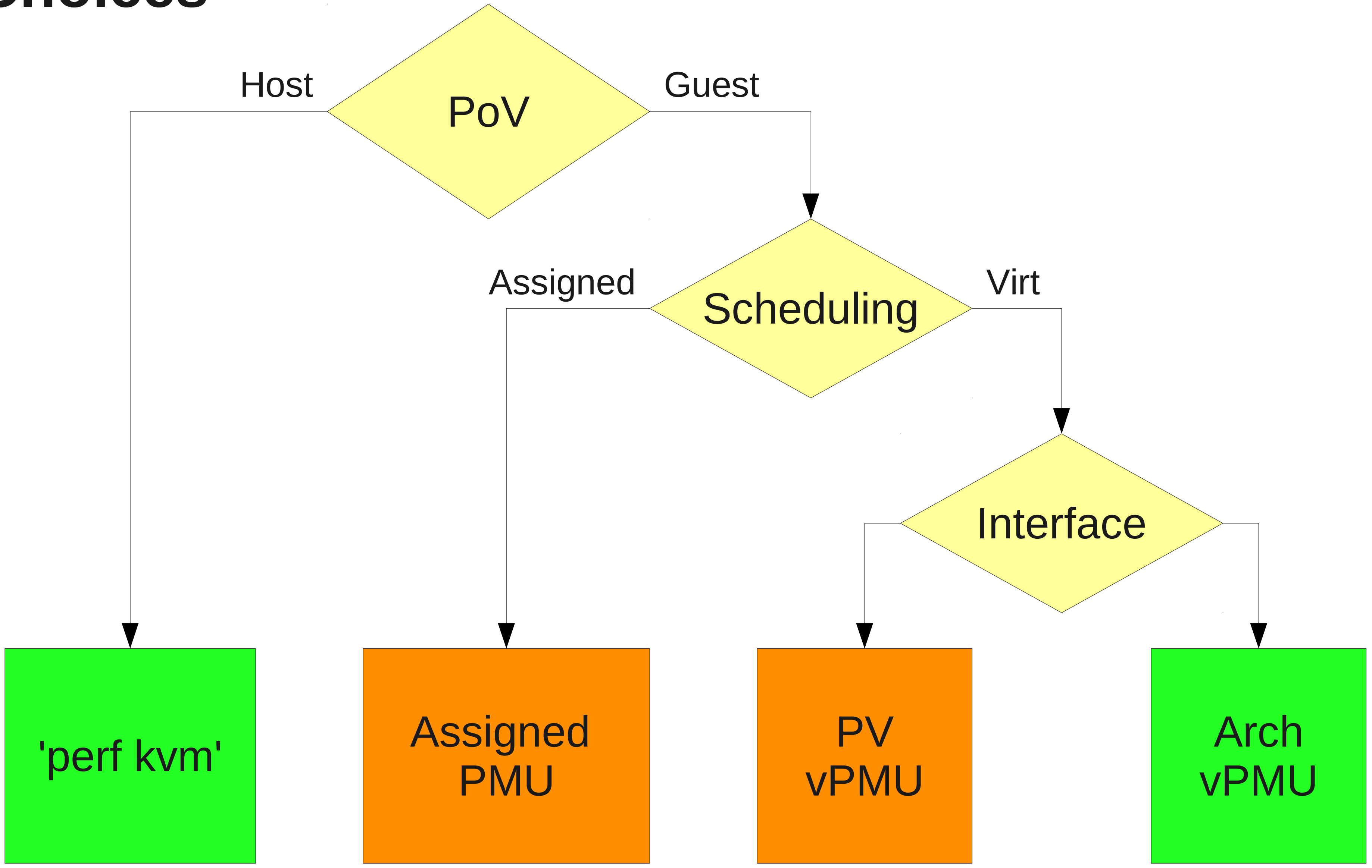
Problems with the x86 PMU

- Vendor specific, model specific
  - = virtualization-unfriendly
- Limited resource
  - Can count many things, but just a few simultaneously
- Slow to program

Architectural PMU

- Small but useful subset of events
- Programming interface fixed (“architectural MSRs”)
- Stable across processor revisions
- Discoverable via CPUID
- Intel only

Choices


Host
PoV
Guest
Assigned
Scheduling
Virt
Interface
'perf kvm'
Assigned PMU
PV vPMU
Arch vPMU

Point of view

- Host
  - See entire system
  - Multiple guests
  - Virtualization layer

- Guest
  - Existing tools and mindset
  - Integration with guest O/S and processes
  - Cloud deployment
  - Live migration

Assigned PMU vs. vPMU

PMU pass through

- Fast
- Accurate

Virtual PMU

- Secure
- Shareable
- Model independent

Interface

Paravirt

- Flexible
- Fast

Architectural

- Documented, established spec
- Compatible with existing guest software
- Compatible with future hardware improvements

Linux perf_events

- Schedules required counters across available PMU counters
- Host-wide counters
- Process counters
- Software counters
- PMU counters
  - Generic
  - Model specific

perf kvm

- Extension of perf_events subsystem to sample guests
- 'perf kvm' tool
- Merged into Linux 2.6.35

Inplementing a vPMU with perf_events

- perf_events generic counters match arch PMU 1:1
  - How convenient
- Some details don't match so well
  - CMASK
- KVM code decodes guest intent from MSR writes
  - ... and asks perf core to monitor these events
- Scheduling, programming done by perf core

Problems

- Few applications work with the architectural PMU
  - Need individual testing and qualification
- Programming the vPMU is slow
  - Can be improved with Version 2 Architectural PMU
- Linux will not try to detect Architectural PMU on AMD
  - Can be fixed

Future work

- Test & merge
- Version 2 (or 3) Architectural PMU
- Paravirt acceleration

Questions

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