
# KVM: Linux-based Virtualization

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# Agenda

- Quick view
- Features
- KVM Execution loop
- Memory management
- Linux Integration
- Paravirtualization
- I/O
- Power management
- Non-x86
- Real time
- Xenner
- Community
- Conclusions

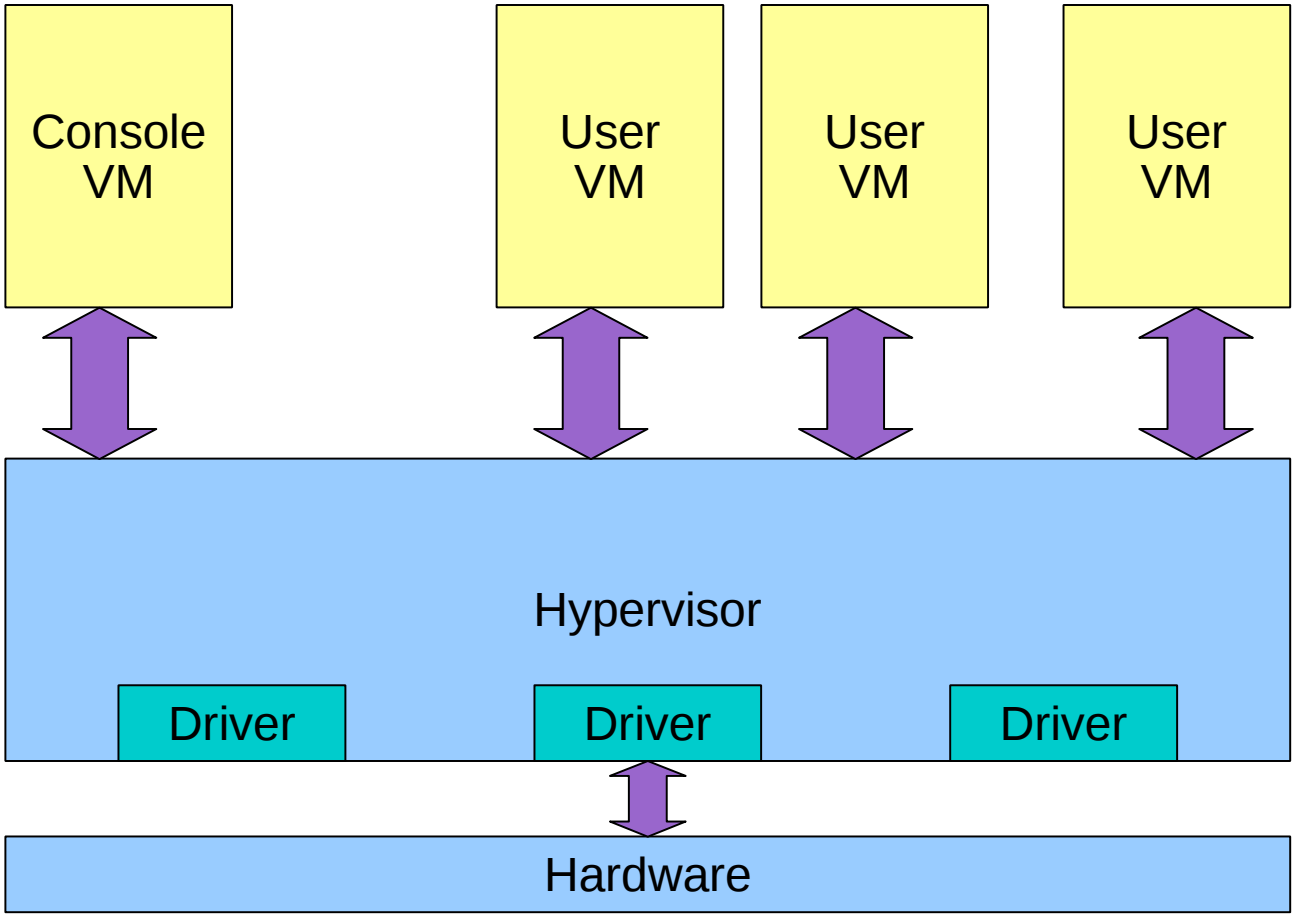
# At a glance

- KVM – the Kernel-based Virtual Machine – is a Linux kernel module that turns Linux into a hypervisor
- Requires hardware virtualization extensions
- Supports multiple architectures: x86 (32- and 64- bit) s390 (mainframes), PowerPC, ia64 (Itanium)
- Competitive performance and feature set
- Advanced memory management
- Tightly integrated into Linux

# The KVM approach

- Reuse Linux code as much as possible
- Focus on virtualization, leave other things to respective developers
- Integrate well into existing infrastructure, codebase, and mindset
- Benefit from semi-related advances in Linux

# VMware



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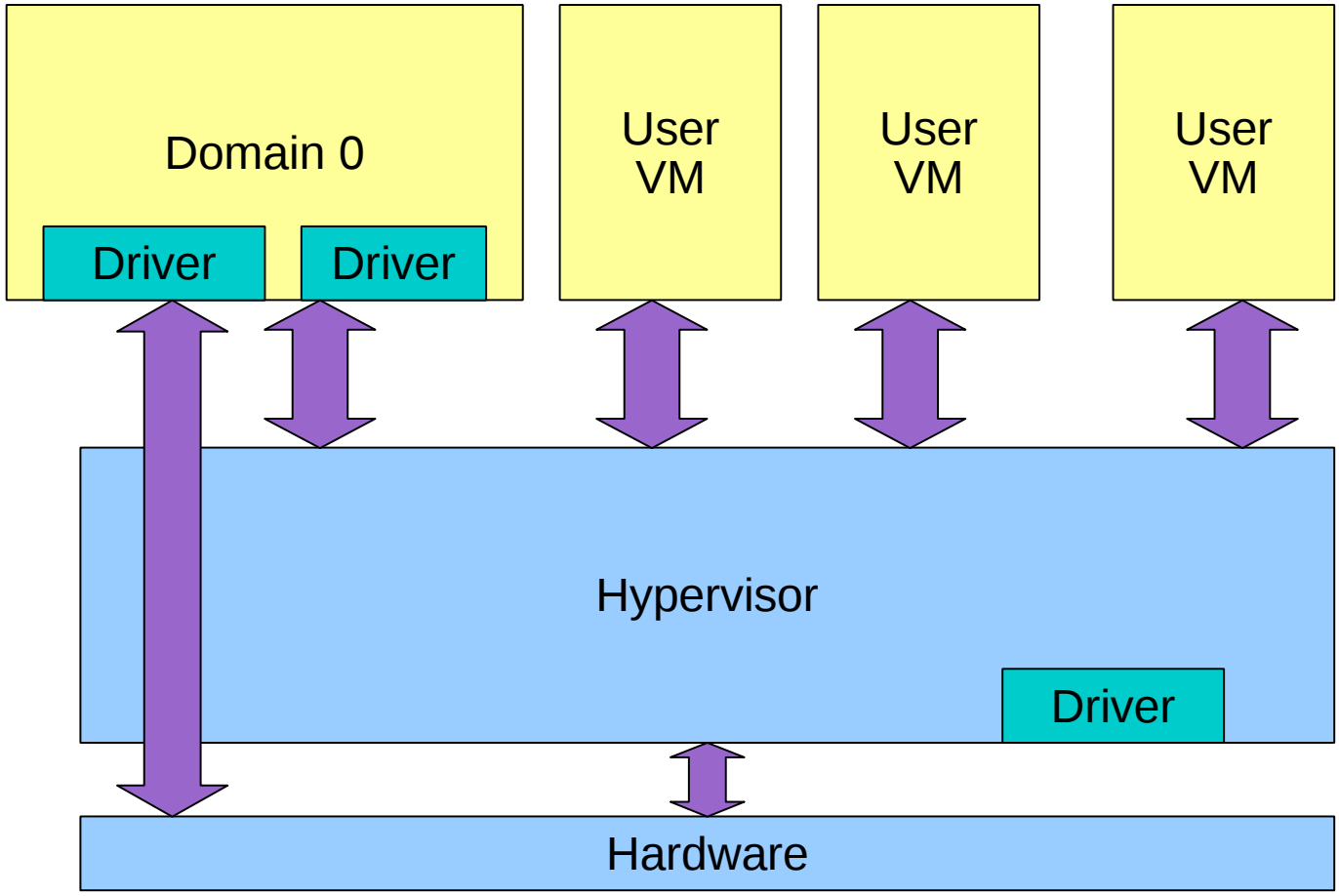
# Xen



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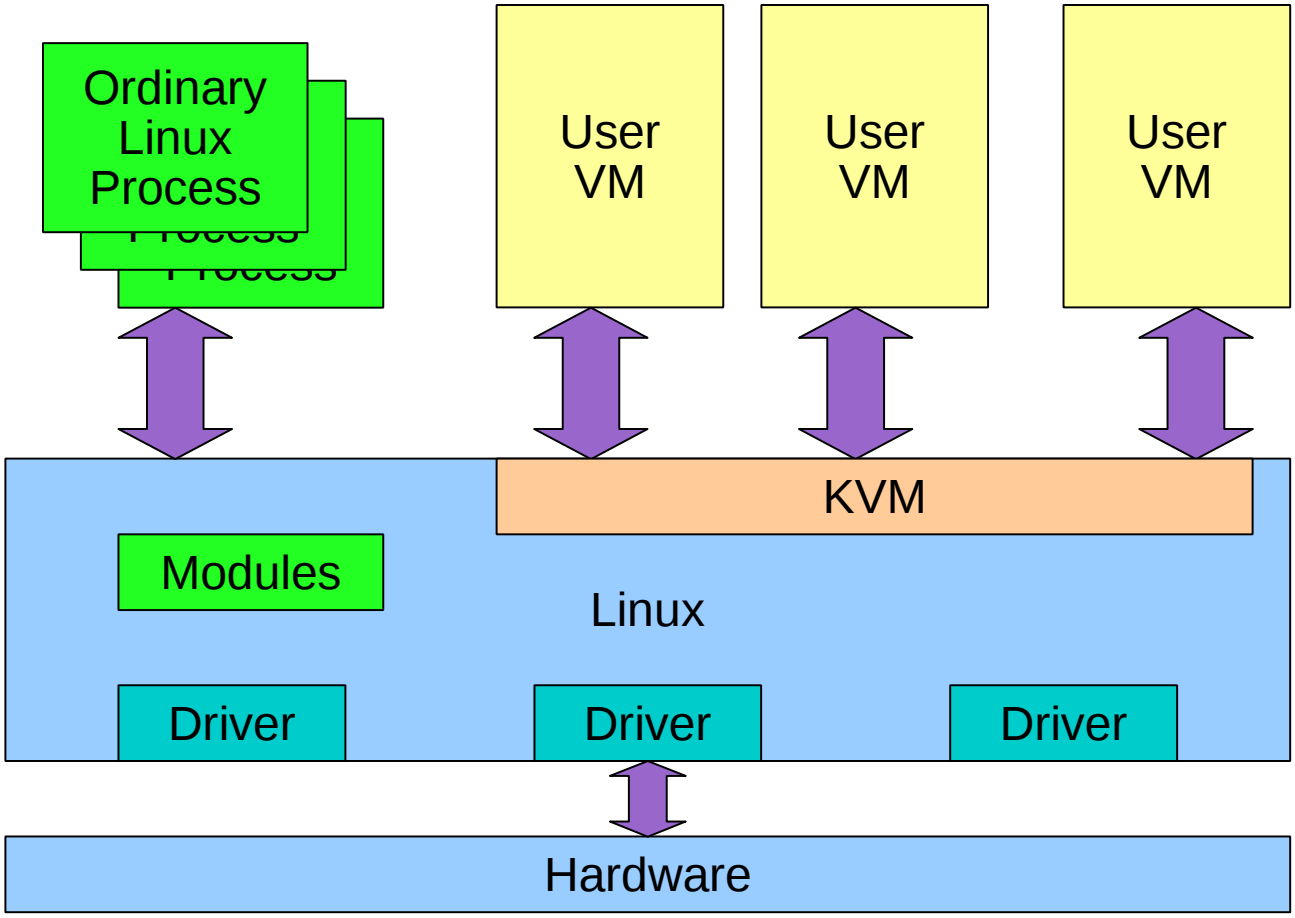
# KVM



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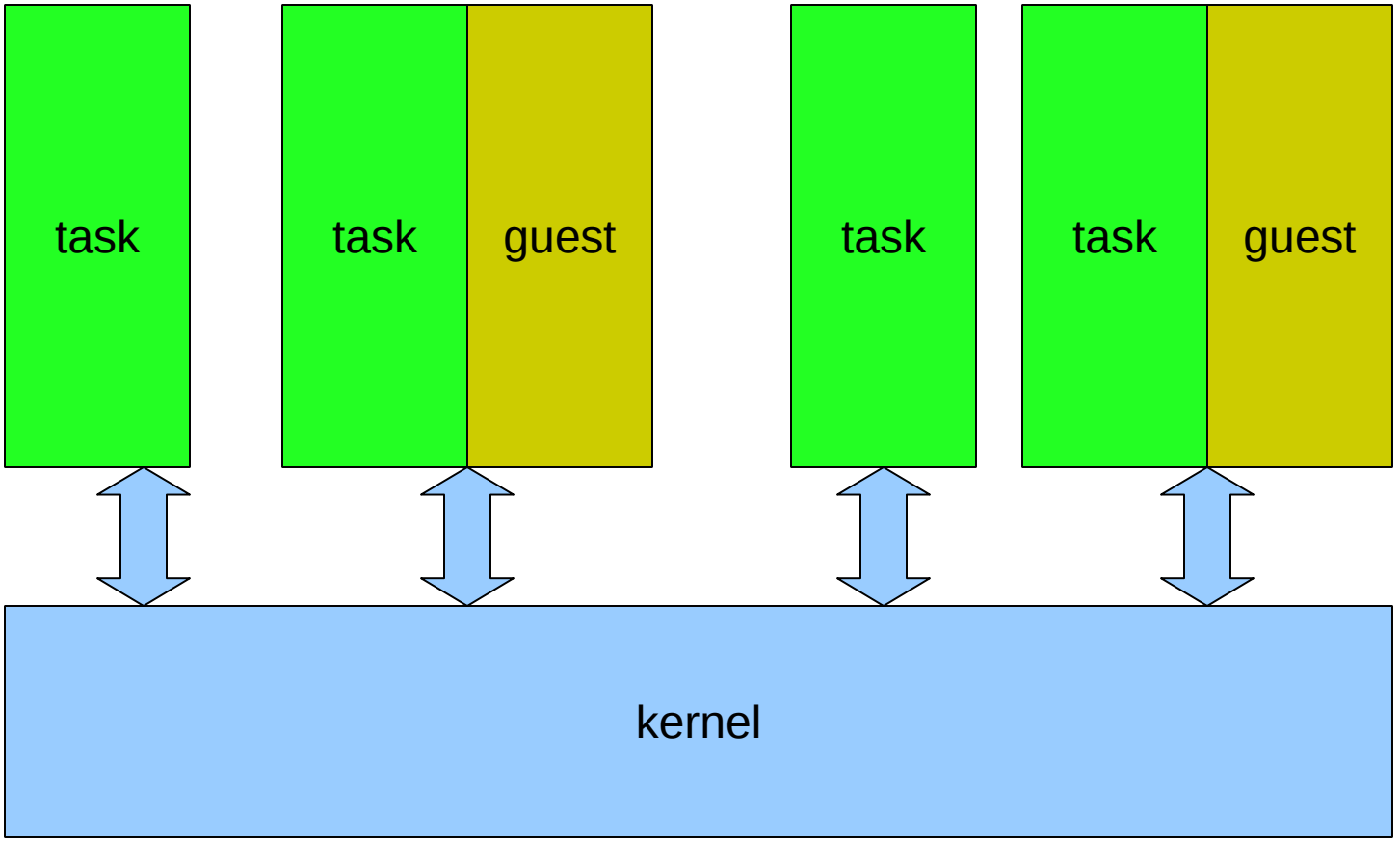
# KVM model enefits

- Reuse scheduler, memory management, bringup
- Reuse Linux driver portfolio
- Reuse I/O stack
- Reuse management stack

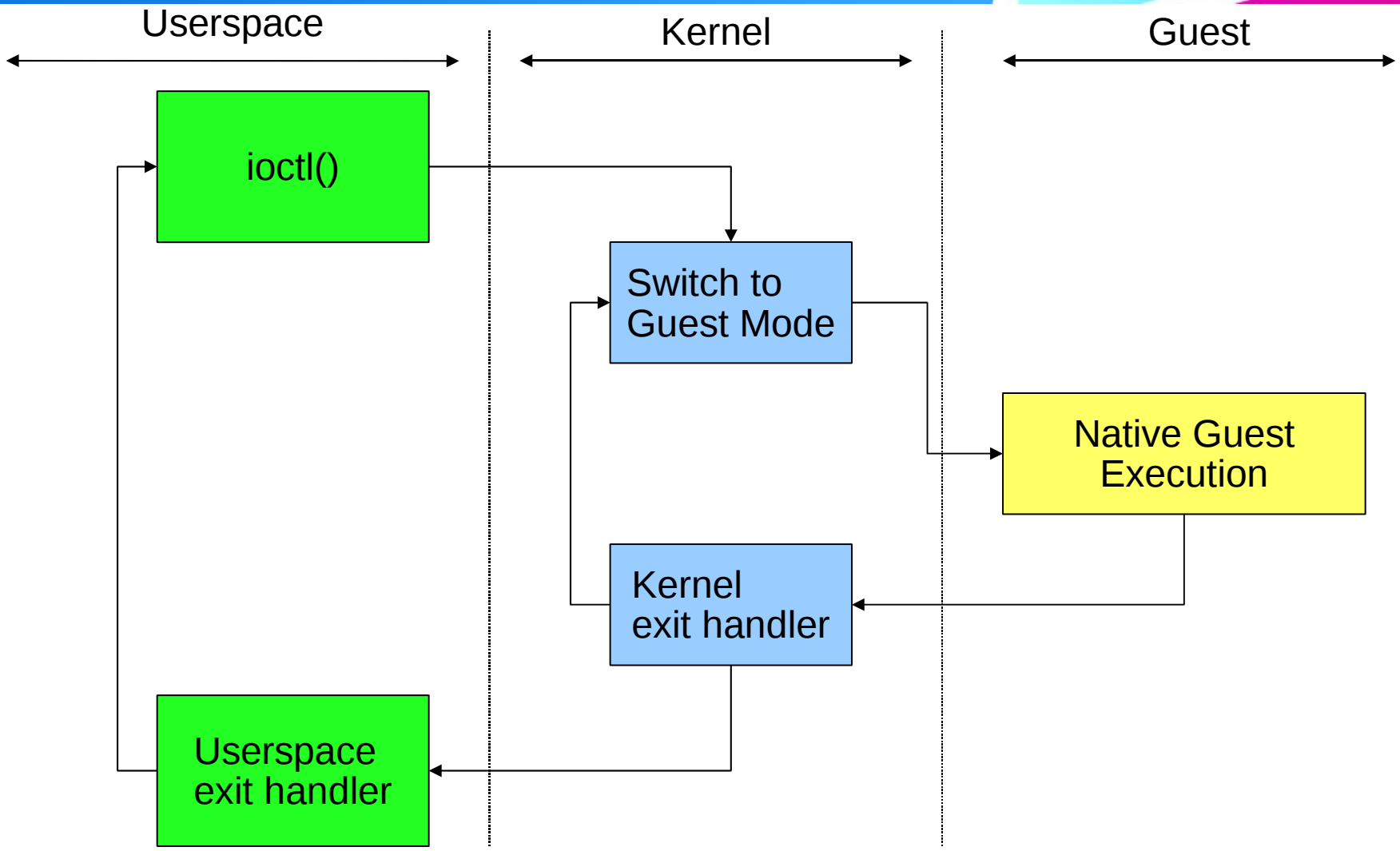
# KVM Process Model



# KVM Execution Model

- Three modes for thread execution instead of the traditional two:
  - User mode
  - Kernel mode
  - Guest mode
- A virtual CPU is implemented using a Linux thread
- The Linux scheduler is responsible for scheduling a virtual cpu, as it is a normal thread

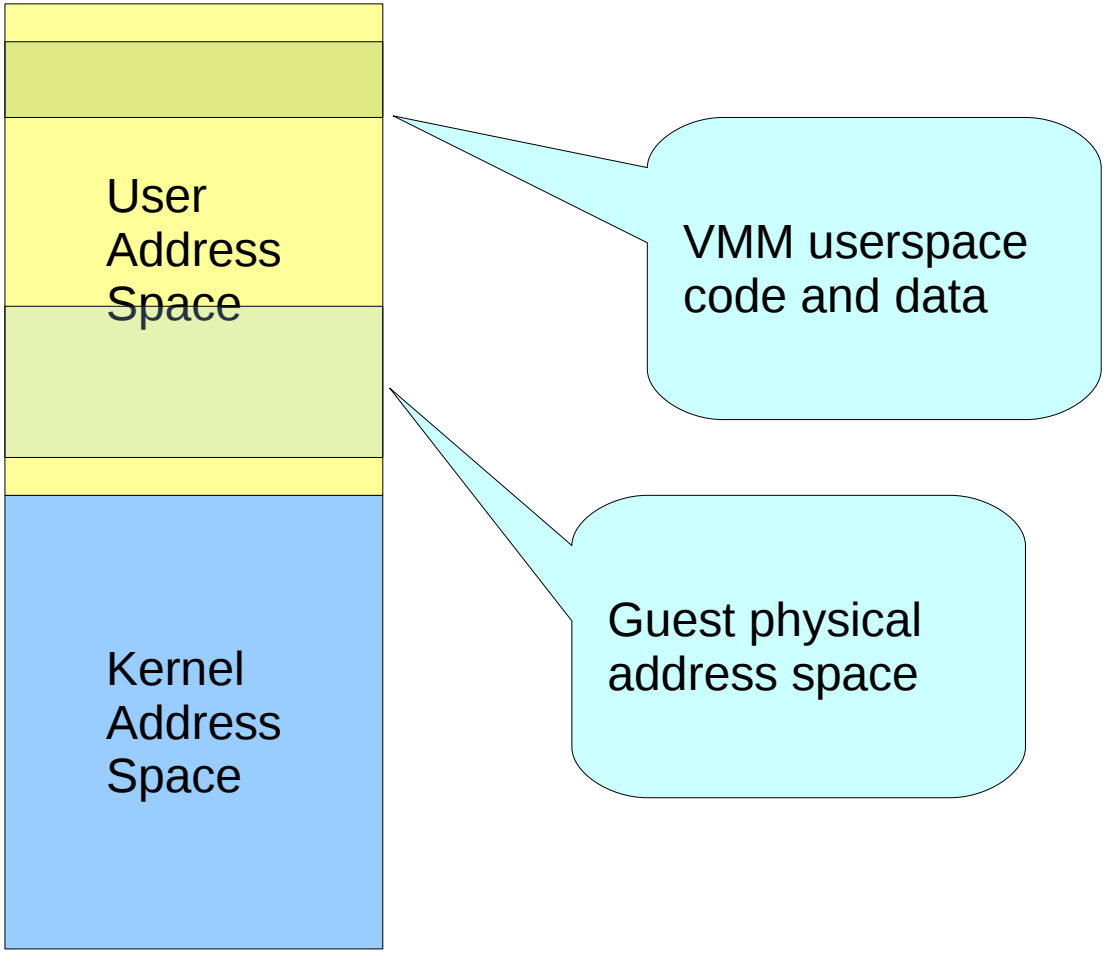
# KVM Execution Model



# KVM Execution Model

- Guest code executes natively
  - Apart from trap'n'emulate instructions
- Performance critical or security critical operations handled in kernel
  - Mode transitions
  - Shadow MMU
- I/O emulation and management handled in userspace
  - Qemu-derived code base
  - Other users welcome

# KVM Memory Model



# KVM Memory Model

- Guest physical memory is just a chunk of host virtual memory, so it can be
  - Swapped
  - Shared
  - Backed by large pages
  - Backed by a disk file
  - COW'ed
- The rest of the host virtual memory is free for use by the VMM
  - Low bandwidth device emulation
  - Management code

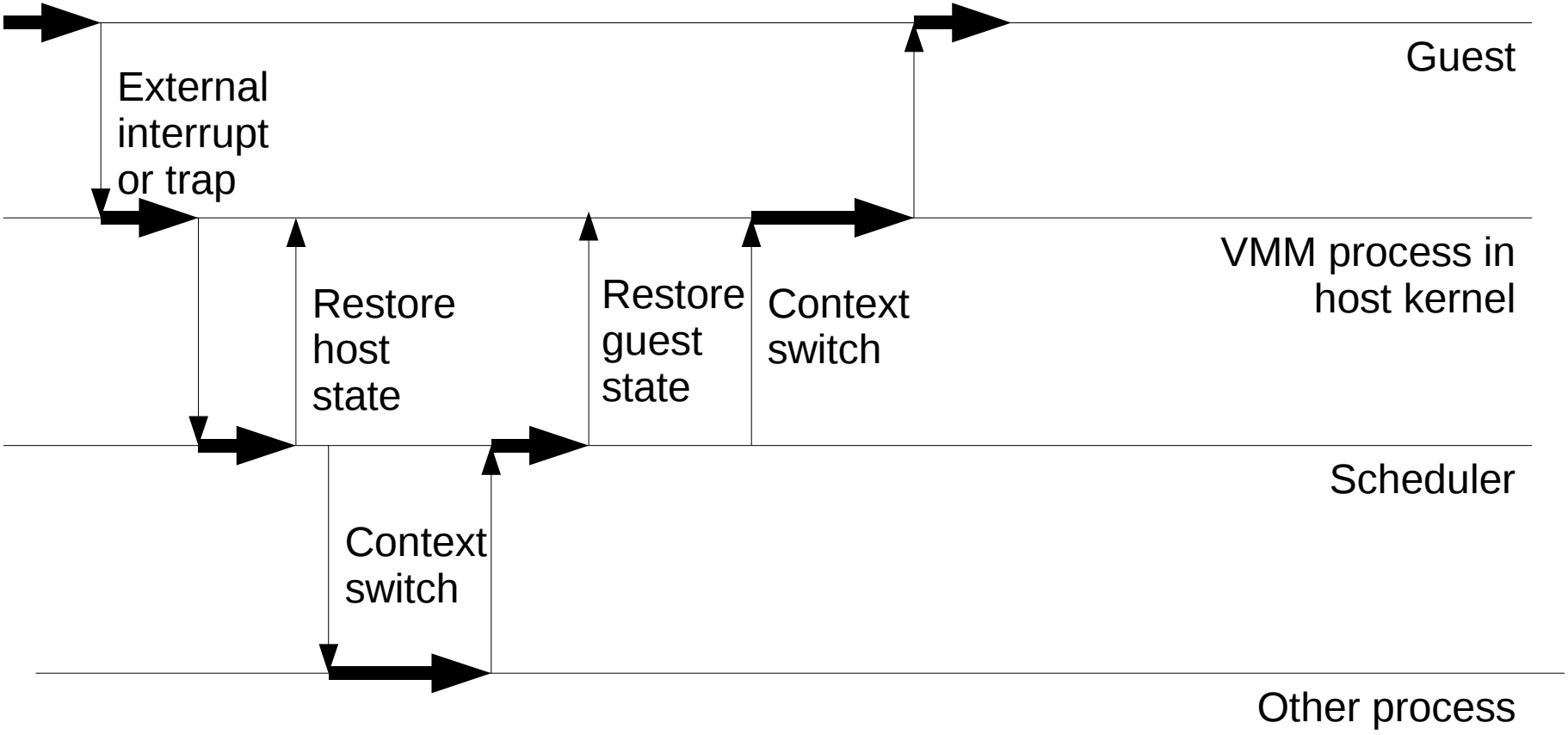
# Linux Integration

- Preemption (and voluntary sleep) hooks: preempt notifiers
- Swapping and other virtual memory management: mmu notifiers

# Preempt Notifiers

- Linux may choose to suspend a vcpu's execution
- KVM runs with some guest state loaded while in kernel mode (FPU, etc.)
- Need to restore state when switching back to user mode
- Solution: Linux notifies KVM whenever it preempts a process that has guest state loaded
  - ... and when the process is scheduled back in
- Allows the best of both worlds
  - Low vmexit latency
  - Preemptibility, sleeping when paging in

# Preempt notifiers



# MMU Notifiers

- Linux doesn't know about the KVM MMU
- So it can't
  - Flush shadow page table entries when it swaps out a page (or migrates it, or ...)
  - Query the pte accessed bit when determines the recency of a page
- Solution: add a notifier
  - for tlb flushes
  - for accessed/dirty bit checks
- With MMU notifiers, the KVM shadow MMU follows changes to the Linux view of the process memory map

# Paravirtualization

- Yesterday's hot topic
  - Needed for decent MMU performance without two-dimensional paging
  - Intrusive
- KVM has modular paravirtualization support
  - Turn on and off as needed by hardware
  - Still needs hardware virtualization extensions
- Supported areas
  - Hypercall-based, batched mmu operations
  - Clock

# Virtio

- Most devices emulated in userspace
  - With fairly low performance
- Paravirtualized I/O is the traditional way to accelerate I/O
- Virtio is a framework and set of drivers:
  - A hypervisor-independent, domain-independent, bus-independent protocol for transferring buffers
  - A binding layer for attaching virtio to a bus (e.g. pci)
  - Domain specific guest drivers (networking, storage, etc.)
  - Hypervisor specific host support

# Power management

- A good example of how Linux integration helps
  - An especially icky area in operating systems
- KVM has
  - Automatic frequency scaling
    - with several governors
  - Suspend/resume support
    - with running virtual machines
- All with a small amount of glue code

# Other cpu architectures

- s390 (aka System Z, aka mainframe)
  - KVM support recently integrated
- ia64 (aka Itanium)
  - ditto
- PowerPC embedded
  - In development
  - Coming soon to a cell phone near you

# Real time

- Linux has (unmerged) hard real time support
- KVM does not interfere with the real time properties of real time Linux
- Can run virtual machines alongside hard real time processes
  - Run a GUI in a container alongside an industrial controller
  - Or a cell phone
  - Or, soak up unused cycles on real-time financials servers

# Xenner

- An independent application that uses KVM
- Emulates the Xen hypervisor ABI
  - Much, much smaller than Xen
- Used to run unmodified Xen guests on KVM

# Community

- Main contributors
  - AMD, IBM, Intel, Qumranet, Red Hat
- Typical open source project
  - Mailing lists, IRC
- Annual Developer's Forum
  - This year at Napa, California in June
- Will love to see you contribute

# Conclusions

- Simple model - no excess baggage
- Fully featured
- Good performance
- Catching up from behind – but at a tremendous pace

Participate at

http://kvm.qumranet.com


# Thank You