KVM on s390: The good, the bad and the weird
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What's this about?

- s390 (aka z Systems®) was the second architecture to implement KVM
- First with a custom userspace (kuli), then with qemu
- KVM on s390 exploits some neat architecture features...
- ...but also had to deal with some decisions that sounded good at the time...
- ...and some rather odd things that are different from everybody else
Let's get started

SIE – Start Interpretive Execution
Let's get started

- SIE uses per-vcpu control blocks in host memory
  - ...this is nice for nested virtualization
- Satellite control blocks for some assists
- Intercept controls to enable manual interpretation
- Cool feature: ibc to fence back to a previous machine generation
- Intercept requests to get a vcpu out of the SIE
  - Headscratcher: We can request exit for stop, I/O and external – but not for machine checks
- Various SIE exits: instruction, program interrupt, idle...
  - ...but mostly mapped to the same exit code in KVM
Let's get started

- (Nearly) everything used to be mapped to a single SIE exit reason
- Drawbacks: we need to fetch state, as we don't know what we need to handle the intercept
  - Instruction intercepts, wait states or program checks all need different status
- New 'specialist' exit codes (for handling of tsch, stsi, …)
- ...but a far cry from the variety of exit reasons on other architectures
Channels and paths and programs
Channels and paths and programs

- virtio
- diagnose 500
- external interrupt
- Guest memory
- stsch
- chsc
- cc 3
Channels and paths and programs

Guest memory

diagnose 500

I/O interrupt

stsch

chsc

ssch

tsch

...
Channels and paths and programs

- CSS
- 0.0.0020
- 0.0.0021
- ccw0
- ccw1
- ccw2
- ...

- 4711
- 4712

11
12
Channels and paths and programs

- stsch, msch, tsch – deal with device descriptions
- ssch, rsch, hsch, csch, xsch – deal with channel programs
- chsc – deal with a whole lot of things
- Neat features:
  - All I/O instructions are mandatory intercepts
  - Common set of architectural descriptions for all devices
  - All I/O devices can describe themselves
Channels and paths and programs

- virtio – the easy case
  - Fully virtual channel subsystem
  - Channel paths do nothing
- Passthrough (vfio) and emulation is more complicated
  - Need 'real' channel paths
  - Some refactoring to accommodate non-virtio devices
  - Vfio-ccw would be a talk in itself
It's PCI, but not as you know it

- PCI is a relative newcomer to the s390
- Only certain cards supported (RoCE, Flash, Compression)
- Needed to fit with existing paradigms
- No MMIO!
- Various instructions for reading/writing memory
- Integration into existing I/O infrastructure (adapter interrupts, channel-subsystem machine checks)
- ...and NO topology information!
It's PCI, but not as you know it

<table>
<thead>
<tr>
<th>You want</th>
<th>You use</th>
<th>You get</th>
</tr>
</thead>
<tbody>
<tr>
<td>All PCI functions and their configuration</td>
<td>CLP List PCI Functions and CLP Query PCI Function</td>
<td>List of functions with FH, FID, UID, BARs and DMA values – NO bus/slot/function topology!</td>
</tr>
<tr>
<td>Read/write PCI config space</td>
<td>PCI LOAD and PCI STORE</td>
<td>Access to the config space – via privileged instructions!</td>
</tr>
<tr>
<td>MSI interrupts</td>
<td>Adapter interrupts and indicators</td>
<td>Message encoded with function index and indicator offset</td>
</tr>
<tr>
<td>Hot(un)plug notifications</td>
<td>Machine-check notified events</td>
<td>Information extracted via a channel-subsystem call – but it is still PCI-specific information</td>
</tr>
</tbody>
</table>
It's PCI, but not as you know it

- Linux guest side integration worked quite well, but...
- ...host side modelling in qemu was not that easy
- Challenge: Reconcile qemu's topology-based modelling with zPCI's information
- Solution: Build a 'fake' topology, add satellite zpci devices to store s390-specific information (fid, uid)
It's PCI, but not as you know it
The changing ways of SIGP
The changing ways of SIGP

- SIGP – Signal Processor
- First implementation: partly in the kernel, partly in userspace
  - This did not play well with keeping cpu state in qemu...
  - ...and was racy between SIGPs
- Moved to userspace, guarded by a capability
  - Privileged program exceptions still handled in the kernel
  - Exception: 'fast' SIGPs which also need access to kernel state
  - But we have to keep the old code around...
- Neat architecture feature: SIGP interpretation
  - For a subset of SIGP calls, we can let the SIE handle it
  - Exitless signalling of other vCPUs → win
The call that wants to be a processor

- SCLP – service-call logical processor
- Takes on many tasks performed by a PC's BIOS/UEFI
- ...but it is a well-specified interface
- In practice, we emulate it as a simple call
  - Send a control block (SCCB), get an (external) interrupt on completion
- Supported features vary with the machine generation
The call that wants to be a processor

- Provide information about the machine
  - Number of cpus, amount of memory, ...
  - ...and a list of facilities that is not completely distinct from cpu facilities
- Allow to dynamically change the machine's current configuration
  - Activate standby cpus, deactivate PCI functions, ...
- Implement a console
  - VT-220 compatible or line mode
- All of this is best implemented in userspace
- qemu models this as a device hierarchy
Let's talk about memory
Let's talk about memory

- We need host kernel support to read/write memory in a correct way
- Reasons:
  - IPTE lock (for DAT)
    - To synchronize against page table changes by the SIE
    - Contained in SIE control block
  - Possible storage key operations
- Solution: introduce an IOCTL (KVM_S390_MEM_OP)
Let's talk about memory

- Get ACSE
- Get IPTE lock
- Perform DAT
- Release IPTE lock

Note:
- Program checks may happen
- Key protection currently not implemented

Check arch/s390/kvm/gaccess.c for the gory details
Thank you!