Nesting KVM on s390x

… nesting nested virtualization on IBM z Systems ®

David Hildenbrand, Software Engineer Virtualization and Linux Development
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IBM

If you're not confused, you're not paying attention.

Tom Peters, Thriving on Chaos: Handbook for a Management Revolution

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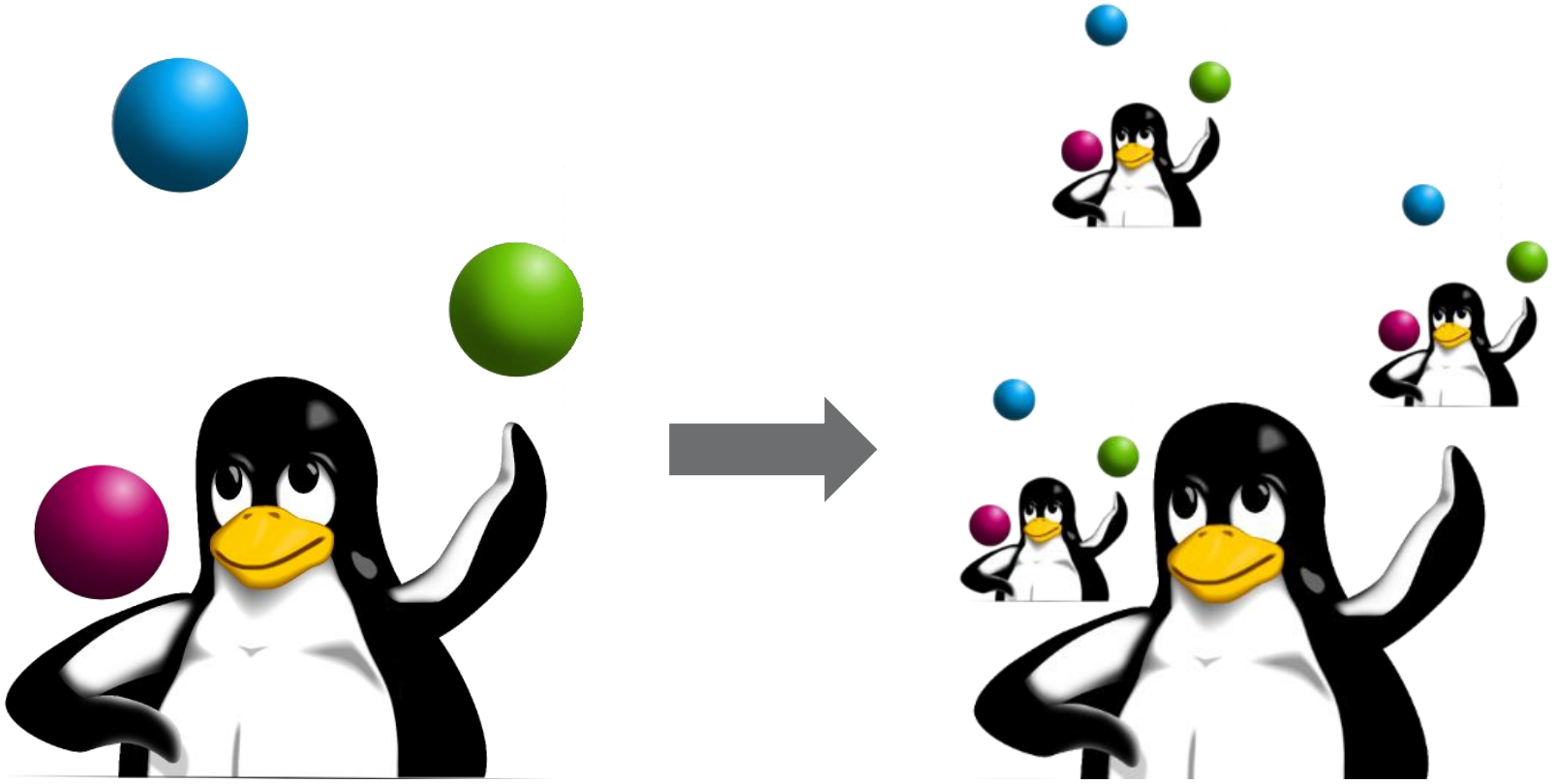
Agenda

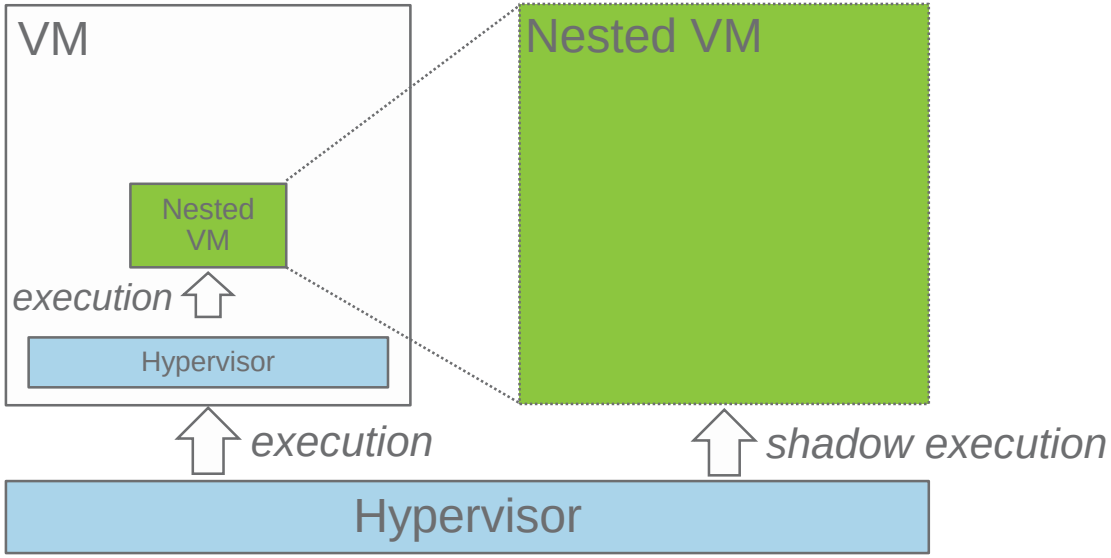
- Nested Virtualization
- Virtualization / KVM on s390x
- Nesting KVM on s390x
- Current status (Features, Migration, Security, Performance)
- Summary and Outlook
- Questions?

Nested Virtualization (1)



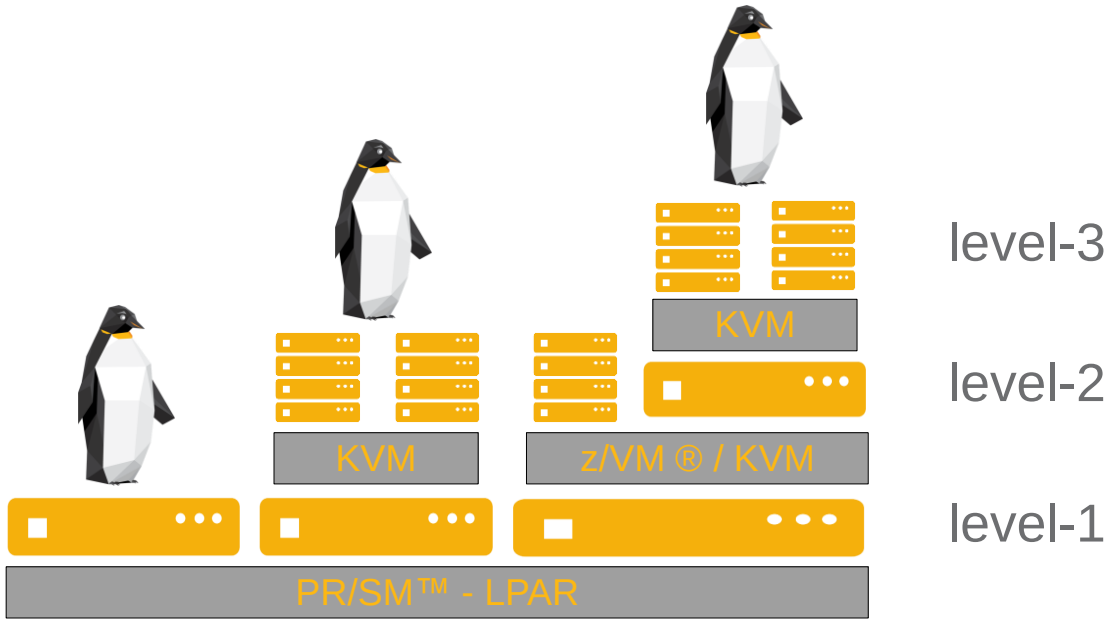
Nested Virtualization (2)

- Turn guest into hypervisor: *run virtual machines*
  - *Test / debug environment* (e.g. for new KVM releases)
  - *Simulate different hardware variants*
- Without HW support for nested virtualization
  - *Trap and emulate* (like „KVM-PR“ e.g. for PowerPC ®) *in guest*
  - *Emulate* HW virtualization (using HW virtualization) *in host*



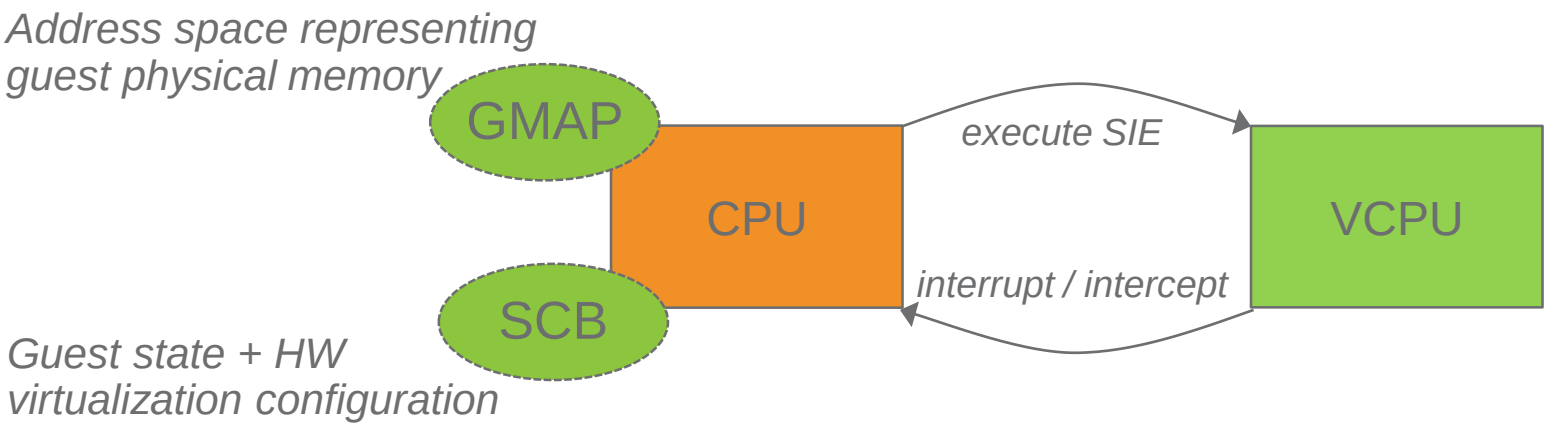
- Nested guest can also run nested guests ... *it usually simply cascades*
- Until now *only x86* emulates HW virtualization in KVM for its guest

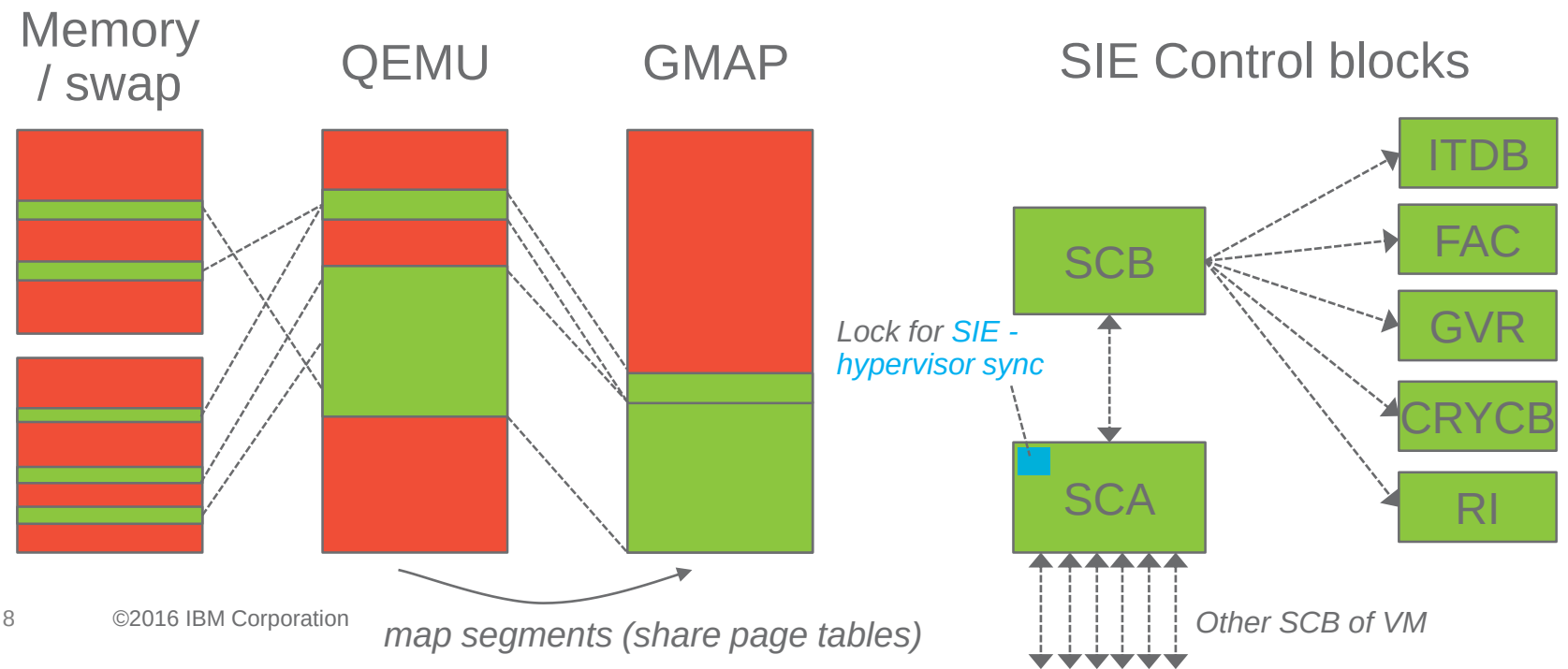
Virtualization / KVM on s390x (1)



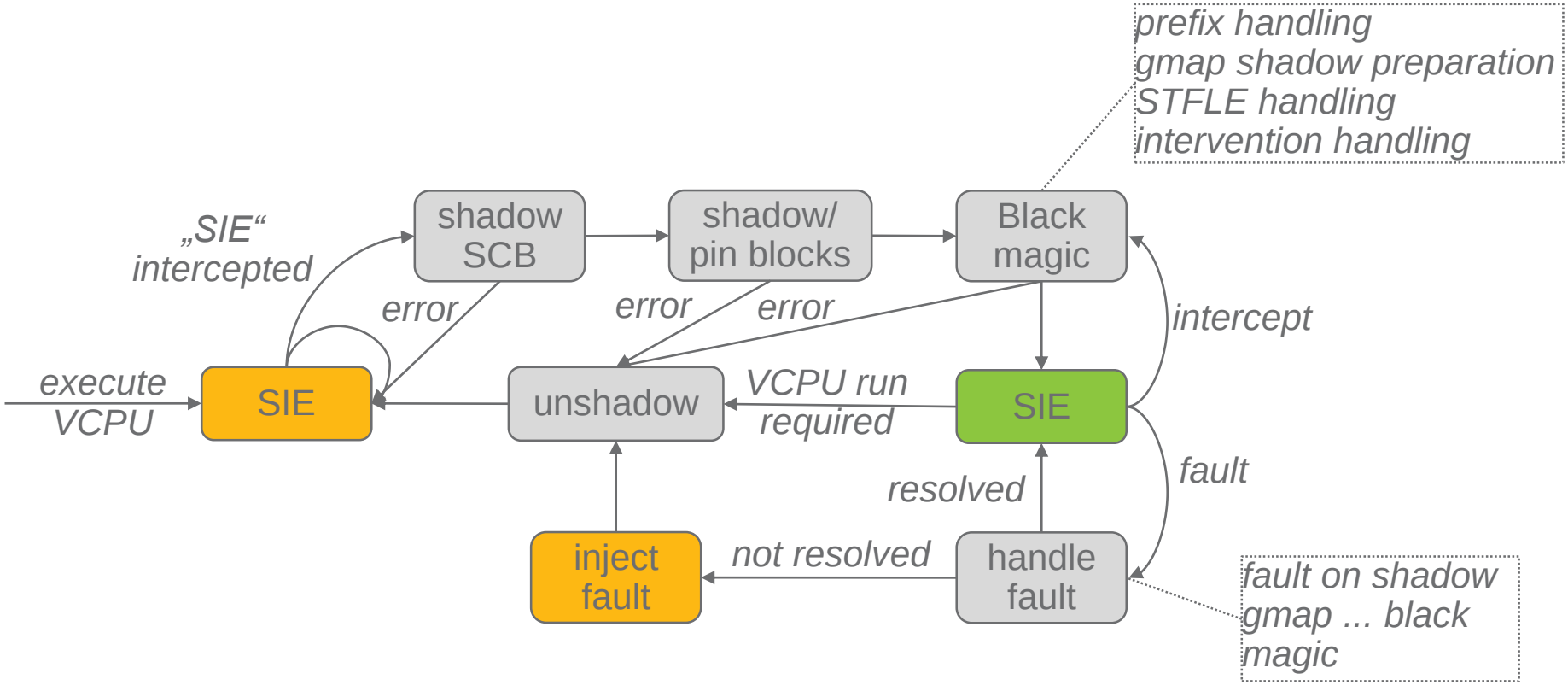
- *At least one level* of virtualization (logical partitioning)
- Hardware provides *support for two levels*
- *SIE (Start Interpretive Execution)* instruction is the entry point to HW virtualization
  - *Interpretes most instructions + guest interrupts*
- *SIE facilities* add aditional interpretation mechanisms (performance / features)

Virtualization / KVM on s390x (2)





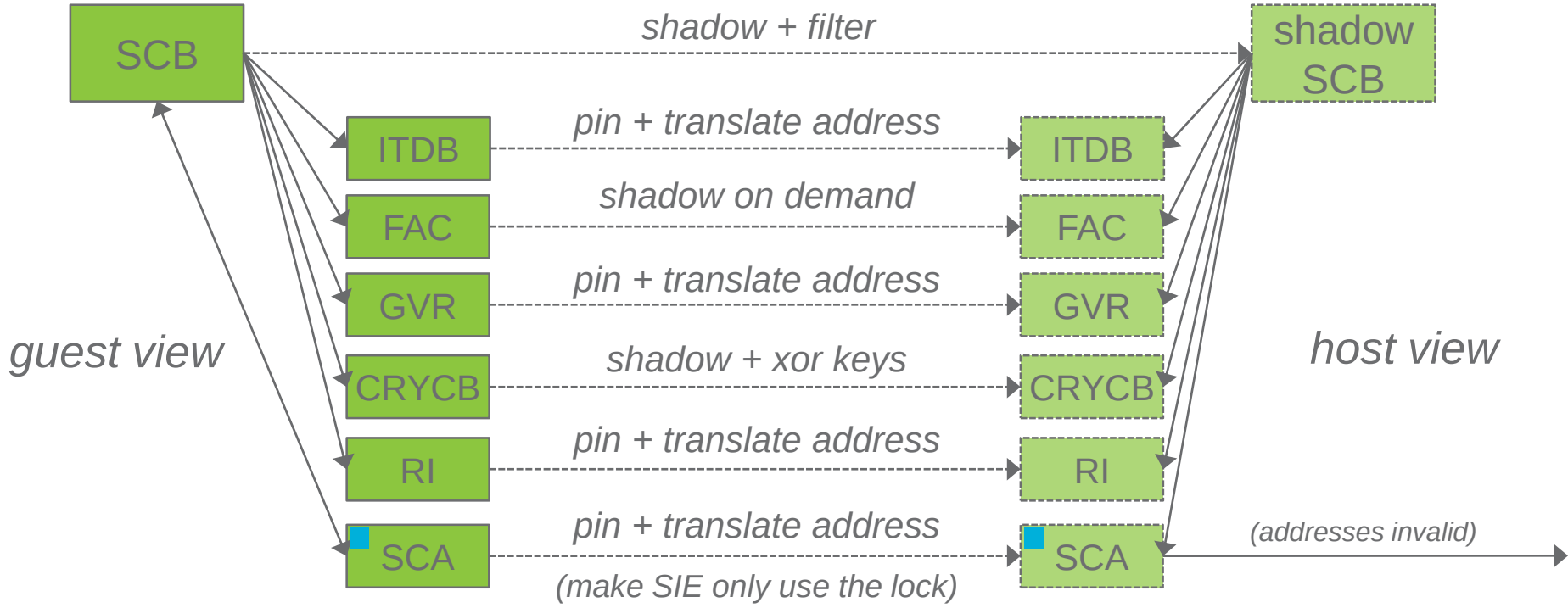
Nesting KVM on s390x (1)



- Emulation is called *Virtual SIE a.k.a vSIE*
- Control blocks / page tables contain *addresses only valid in the guest*
  - *Create shadows in the host*, containging valid host addresses
  - SCB vs. Shadow SCB
  - GMAP vs. Shadow GMAP

Nesting KVM on s390x (2)

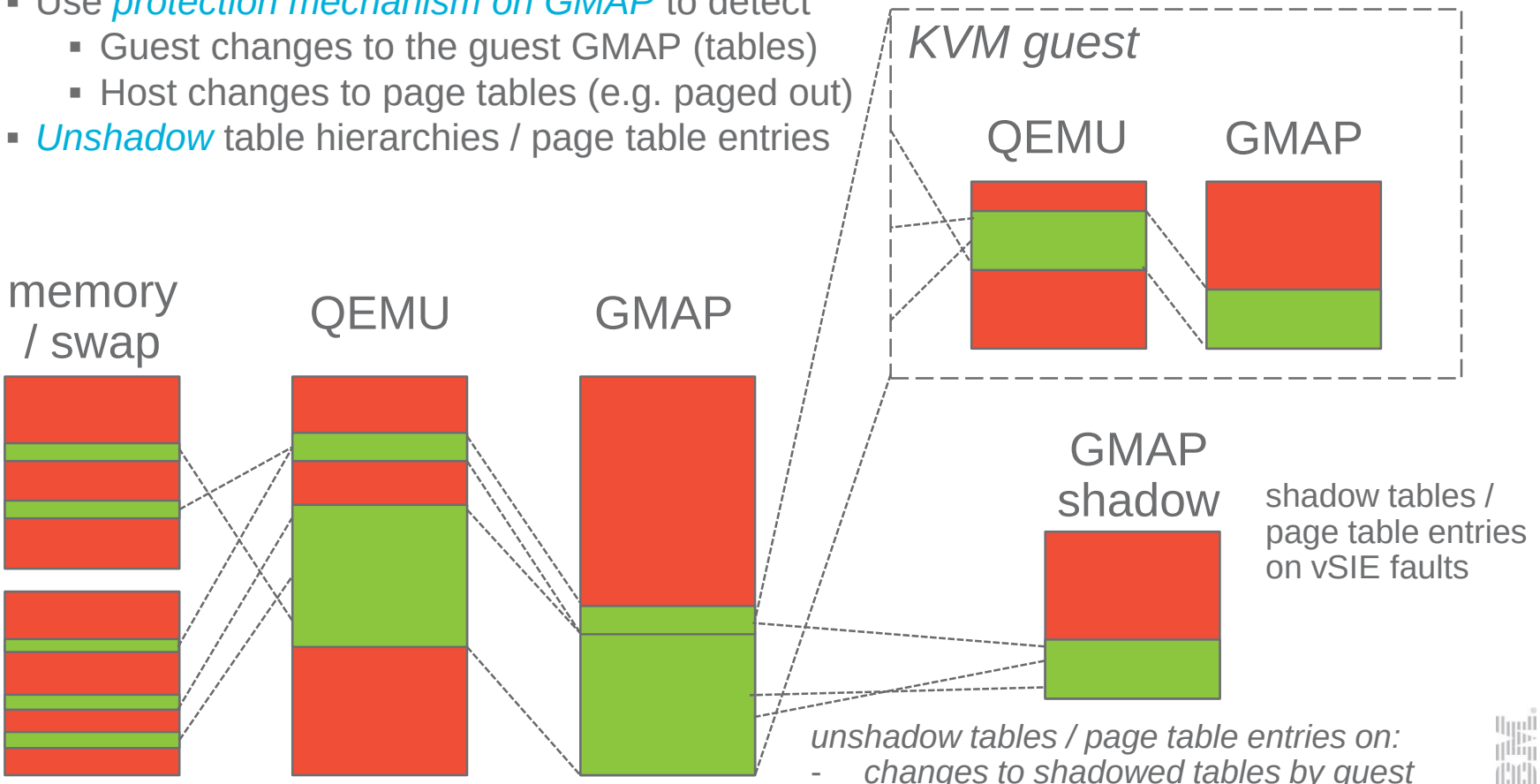
1. *Intercept SIE instruction* executed by KVM guest VCPU
2. *Validate/Copy/Filter* provided SCB, creating a *shadow SCB*



3. *Pin/Shadow/Filter satellite control blocks* referenced in the SCB
   - 31bit addresses in the SCB: shadow on DMA page ☹
4. *Execute the SIE* using the shadow SCB and shadow gmap

Nesting KVM on s390x (3)

4. *Fill/manage GMAP shadow* on *vSIE faults*
   - Create *shadow table hierarchy*
     - Walk guest provided tables by *reading in guest memory*
     - All tables are *initially empty* and *filled on demand (shadowing a lower level table)*
   - Lowest level (page tables) reference real host pages
   - Use *protection mechanism on GMAP* to detect
     - Guest changes to the guest GMAP (tables)
     - Host changes to page tables (e.g. paged out)
   - *Unshadow* table hierarchies / page table entries



Nested KVM on s390x (4)

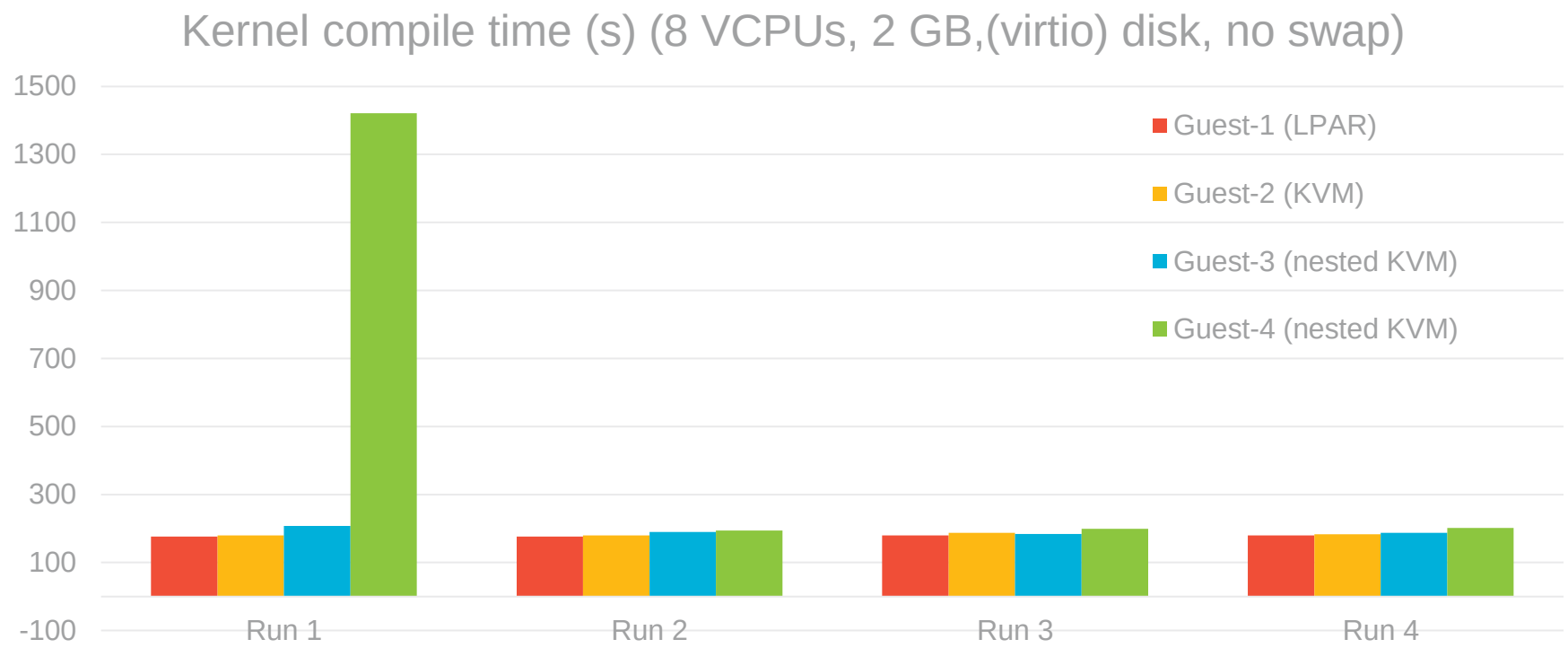
5. *Re-execute the SIE* as long as possible (VCPU run not required)
6. Inject interrupts *into the KVM VCPU guest only* if required (due to vSIE faults)
   - We never inject anything into the nested KVM guest VCPU
7. *Unshadow/unpin* control blocks
   - Unpin sattelites only – *no other blocks have to be unshadowed*

8. *Re-execute KVM guest VCPU*

Current state

- >= 248 CPUs, transactional execution, vector registers, huge pages (1M, 2G) ...
  - Basically everything a KVM guest has, except CMM because ...
- vSIE doesn‘t support all SIE facilities (e.g. CMMA or SIGP interpretation like z/VM)
  - shadow *table entries could be empty* although they are not in the shadowed one
  - SCA contains pointers to invalid SCBs – shadowing is not an option
- No, known bugs – still *„kvm.nested=1“* required for now
- *No know „incompatibilities“* with the SIE specification (okay, there is a small one ...)
- *CPU model support* required to turn it on (*„-cpu host“*)
- *Migration simply works*: guest memory contains all nested guest state
  - Shadow structures (GMAP, SCB ...) are silently recreated on the new host
  - GMAP shadow code should be able to deal with *user fault just fine*
- *Really hard to break out of vSIE, even into its hypervisor:*
  - We don‘t emulate any vSIE instructions – *SIE handles everything for us*
  - We don‘t inject any vSIE interrupts – *SIE handles everything for us*
  - When shadowing, we *heavily filter the SCB*, to not allow e.g. strange addressing modes
  - GMAP shadow is *based on GMAP only*

Performance



- *LPAR: 8 CPUs (not dedicated), 8 GB, SCSI disks, no swap*
- *First memory access is expensive*
  - The GMAP shadow has to be filled on first memory access
  - Building a GMAP shadow on a GMAP shadow is horribly expensive (Guest-4)
- Once memory is faulted into the gmap shadow, *overhead is quite small*
  - *Lockless lookup/reuse* of shadow SCB (to avoid TLB flush) + shadow gmap
- Kernel src on *multi-paravirtualized disk* via virtio-blk
  - Rebooting the compiling guest (clear caches) didn‘t affect compile times

How deep can we go?

Source: ***http://paisleymagic.storenvy.com****/collections/236287-nesting-dolls/products/1447594-penguins-nesting-eco-friendly-doll-russian-dolls-matryoshka*

Summary and Outlook

- I was able to *start a kernel in guest-6* ... while having lunch
  - Can we improve the gmap shadow/unshadow + pagefault pingpong somehow?
- KVM is now able to run with a *minimum amount of SIE facilities*
- We found *one random memory overwrite* + minor bugs in KVM code
- Can we *reduce the amount of DMA pages*?
  - This would allow us to keep more shadow SCBs in the cache
- Can we *reuse data in the shadow SCB*, not shadow/check everything again?
- *„kvm.nested=1“*, can it ever be dropped completely?
- *CPU model support* in QEMU to finally turn it on
- Support all *new HW features as KVM support is added*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Thank you!
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