RAM is getting more complex

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Topics

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Command line memory specification

‘All of RAM/memory’

Sharing

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Types of host memory

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Huge Pages

Encryption

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Types of memory

- RAM
- ROM
- Device memory
  - RAM in devices (e.g. Video RAM)
    - May have different alignment or caching rules
  - Emulated devices
  - Real devices
- Flash devices
  - Mostly like ROM, but with special indirect-write tricks
- Persistent memory
  - Mostly like RAM, but…..

Types of host memory

- Anonymous
  - Normal mmap
- File backed
  - ‘file’ hides many things:
    - Real files (rare)
    - Shmfs RAM filesystems
    - Hugetlbfs HUGE TLB pages
    - Persistent memory (pmem) backed
  - Note: ROMs are normally anonymous loaded from file

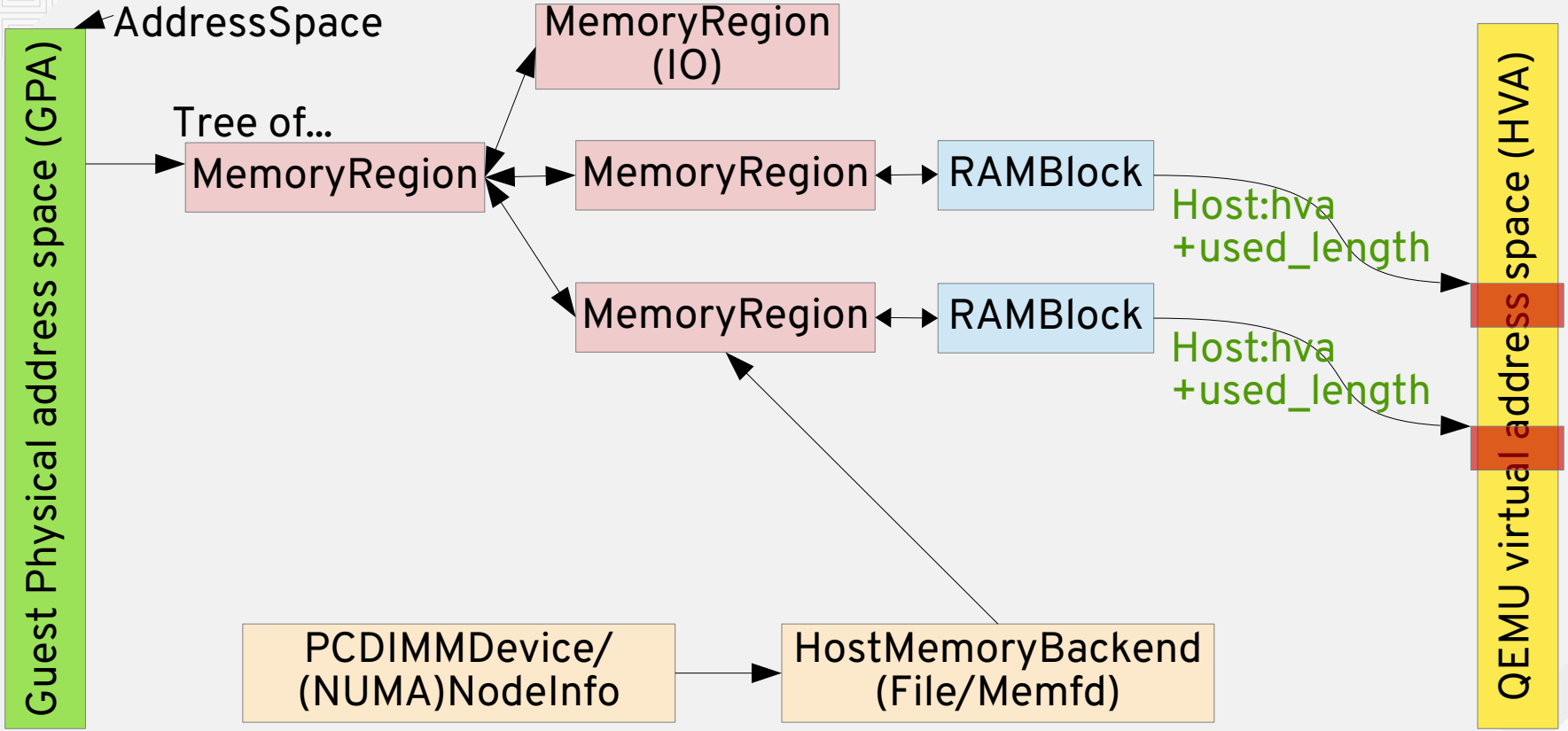
Command lines and memory

- `-m 4G` or `-m size=4G`
- `-m 4G,slots=3,maxmem=1T`
- `-mem-path /dev/hugepages`
- `-mem-path /dev/hugepages/foo`

Falls back to normal memory unless Used with -mem-prealloc

- `-m 8G -object memory-backend-file,id=mem,mem-path=/dev/hugepages,size=8G -numa node,nodeid=0,memdev=mem`
- `-m 4G,slots=4,maxmem=16G -object memory-backend-ram,id=m1,size=1G -device pc-dimm,id=d1,memdev=m1`
- `-M …,nvdimm -m 4G,slots=4,maxmem=16G -object memory-backend-file,id=n1,size=4G,mem-path=/…/… -device nvdimm,id=ndimm1,memdev=n1`

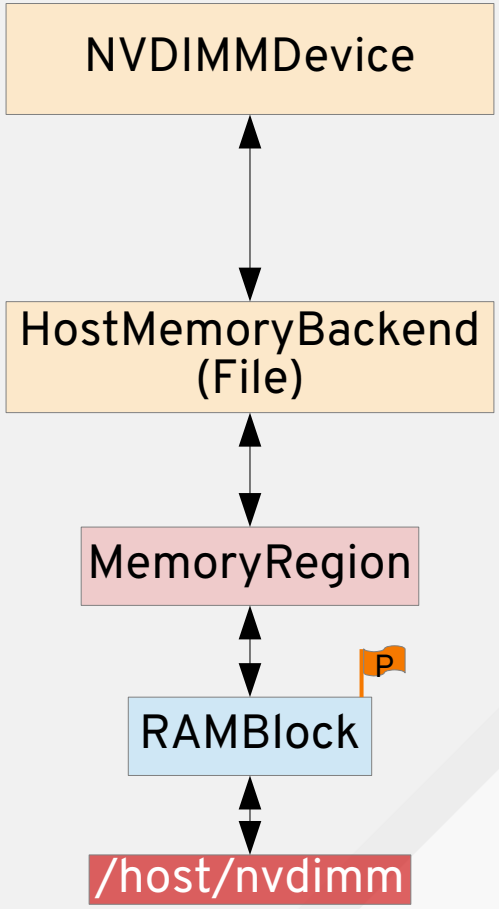
QEMU data structures



Persistent Memory (aka pmem)

- Various rules to ensure consistency when accessing
  - See libpmem
  - QEMU must call libpmem after some of it's own writes (e.g. migration)
- Typically come as 'NVDIMMs'
- Guest sees areas marked by ACPI
- a) QEMU can use pmem as backing storage for RAMBlock's
- b) QEMU can create virtual NVDIMMs in the guest
- c) Can pass persistence flags to guest
- (a) & (b) are mostly independent
  - e.g. just use NVDIMM as more guest RAM and ignore persistence

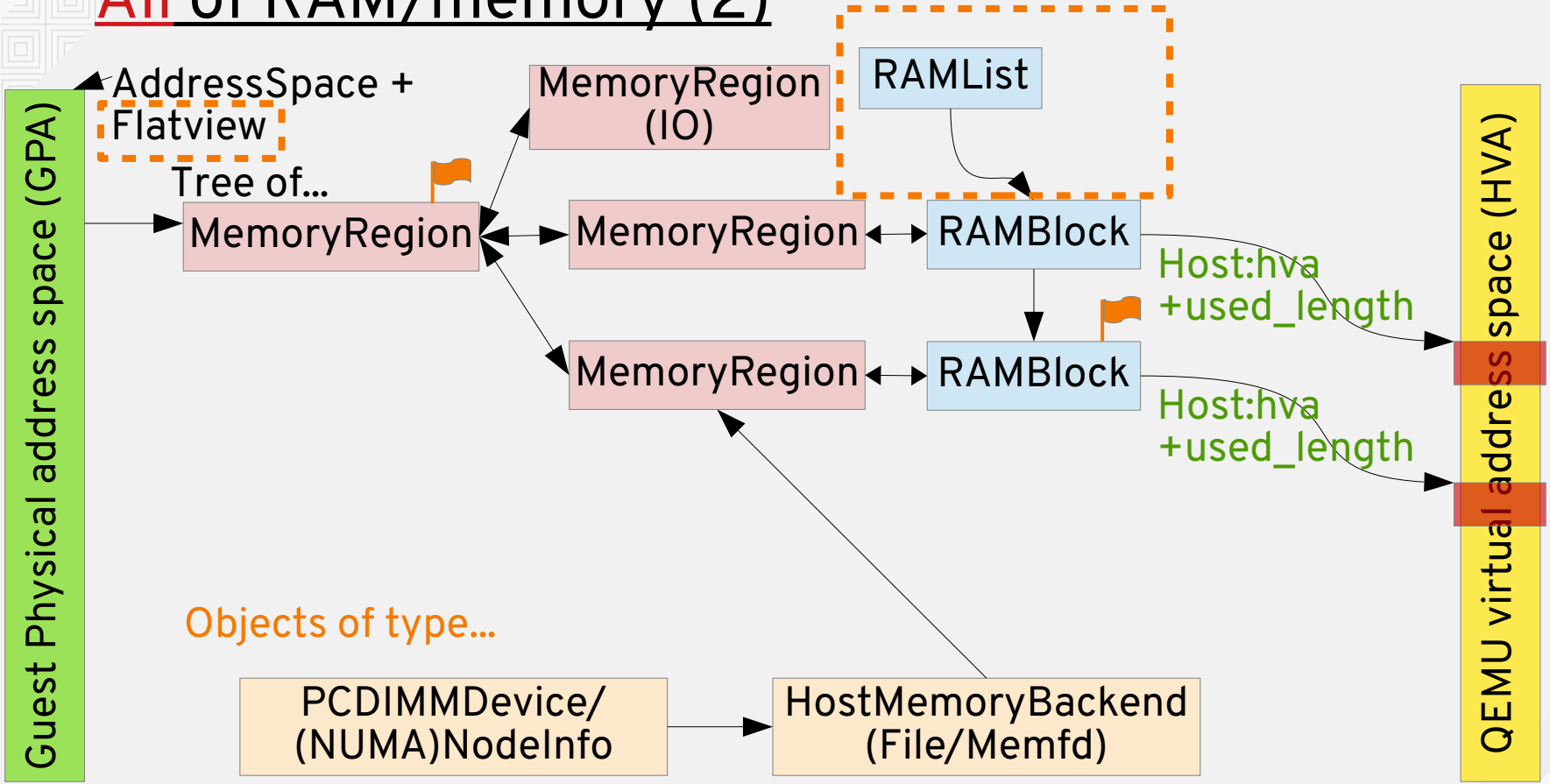
    e.g. fake NVDIMM as seen by guest



‘All of RAM/memory’

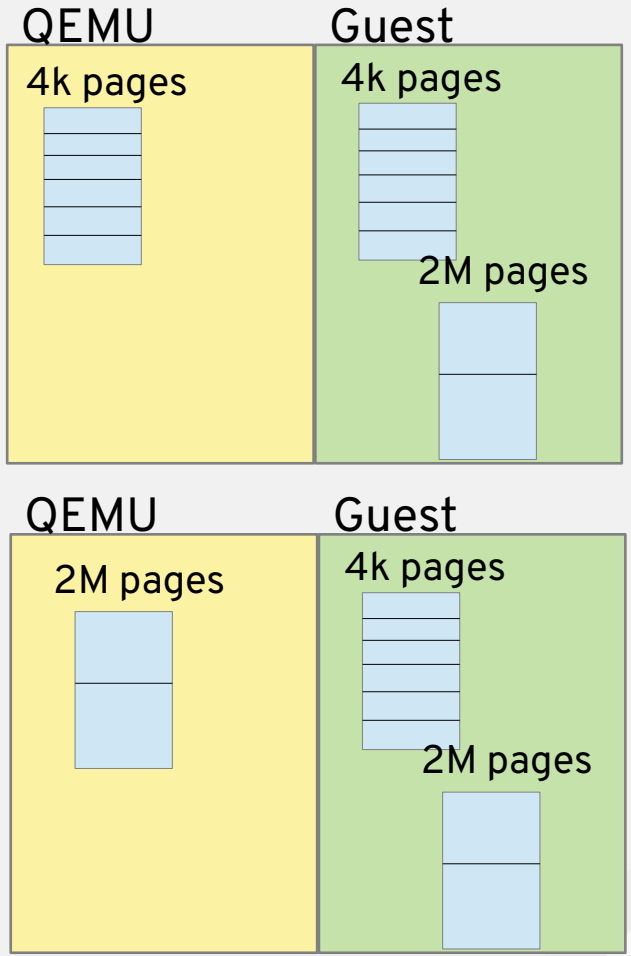
- All RAMBlock’s?
- All guest visible ?
  - Not all RAMBlocks are mapped, some dynamically
- All of one address space?
- Include persistent memory?
  - Decided by backing or guest view?
- ROMs?
  - What about pflash?
- Video RAM?

All of RAM/memory (2)



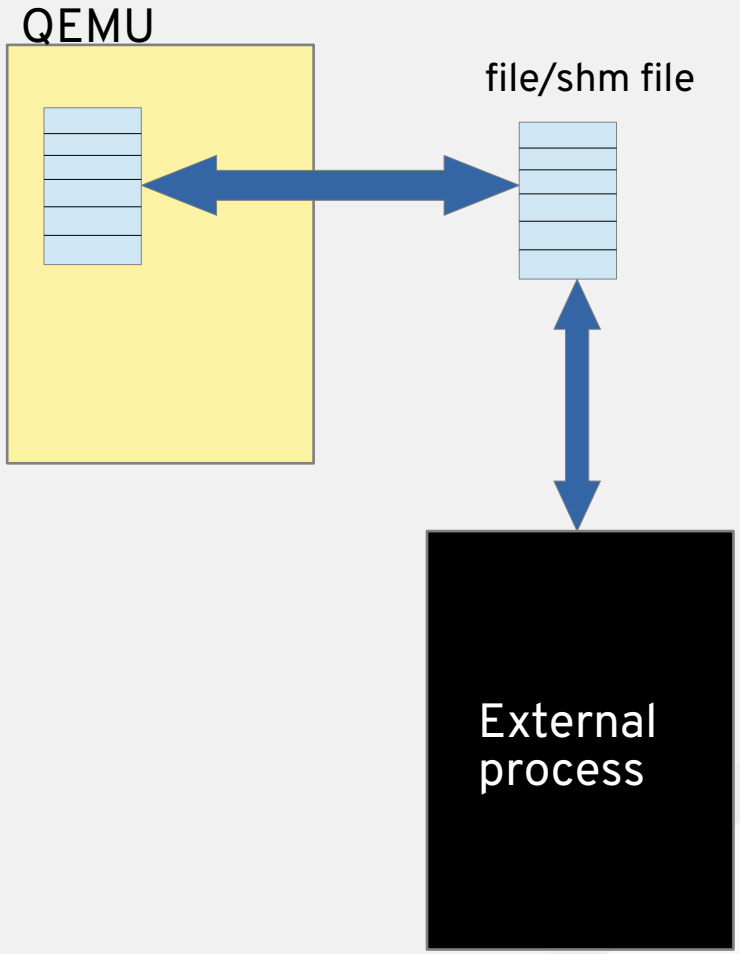
Huge pages

- Properties of individual RAM blocks
  - Can have a mix of some huge, some normal, different sizes of huge
- Guest and Host huge page are separate issues
  - Although some architecture specific restrictions (e.g. Power doesn't allow guest pages larger than host)
  - X86 allows any mix
- Page sizes architecturally dependent



Sharing

- Shared with another process
- Typically vhost-user
- Per-RAM block – but typically used for all main RAM when used.
- Difficult for QEMU to track users
- Sometimes shared by filename, sometimes by fd passing
- Needs some help for QEMU to track external dirtying



Encrypted guest RAM

- AMD's SEV
  - Most of guest memory encrypted
  - Not (usefully) readable by QEMU
  - Guest allows some areas to be accessed for IO
  - Process of measuring BIOSs etc

Migration

- Dirty page flags
  - At ‘target page’ granularity (typically 4k)
  - Some architectures dirty whole hugepage for one write
- Naming
  - RAMBlock names are part of the stream
  - Assigned only when marked for migration, typically when connecting ***frontend*** – can have unnamed RAMBlocks
- Postcopy needs kernel support for different backends
  - Now has normal, hugepage and shared support
  - Other backing files may need kernel support (e.g. pmem)

Useful HMP commands

- info ramblock

```
           Block Name     PSize              Offset               Used              Total
               pc.ram     4 KiB  0x000000000c800000 0x0000000040000000 0x0000000040000000
          /objects/m1     4 KiB  0x0000000000000000 0x0000000006400000 0x0000000006400000
0000:00:02.0/vga.vram     4 KiB  0x000000004c880000 0x0000000001000000 0x0000000001000000
```

- info mtree

```
address-space: memory
  0000000000000000-ffffffffffffffff (prio 0, i/o): system
    0000000000000000-000000003fffffff (prio 0, i/o): alias ram-below-4g @pc.ram
                                                     0000000000000000-000000003fffffff
    0000000000000000-ffffffffffffffff (prio -1, i/o): pci
      00000000000a0000-00000000000bffff (prio 1, i/o): vga-lowmem
      00000000000c0000-00000000000dffff (prio 1, rom): pc.rom
```

- info memdev
  - Backends e.g. HostMemoryBackendFile
- info memory-devices
  - Frontends e.g. PCDimm

Conclusion

- There are now lots of special cases
- Special types of host memory mapping
- Different types of memory devices visible to the guest
- Limitations on different architectures
- Different expectations on the lifetime/preservation of memory contents
- They can all combine into more special cases

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THANK YOU