Quo Vadis Virtio?

2016

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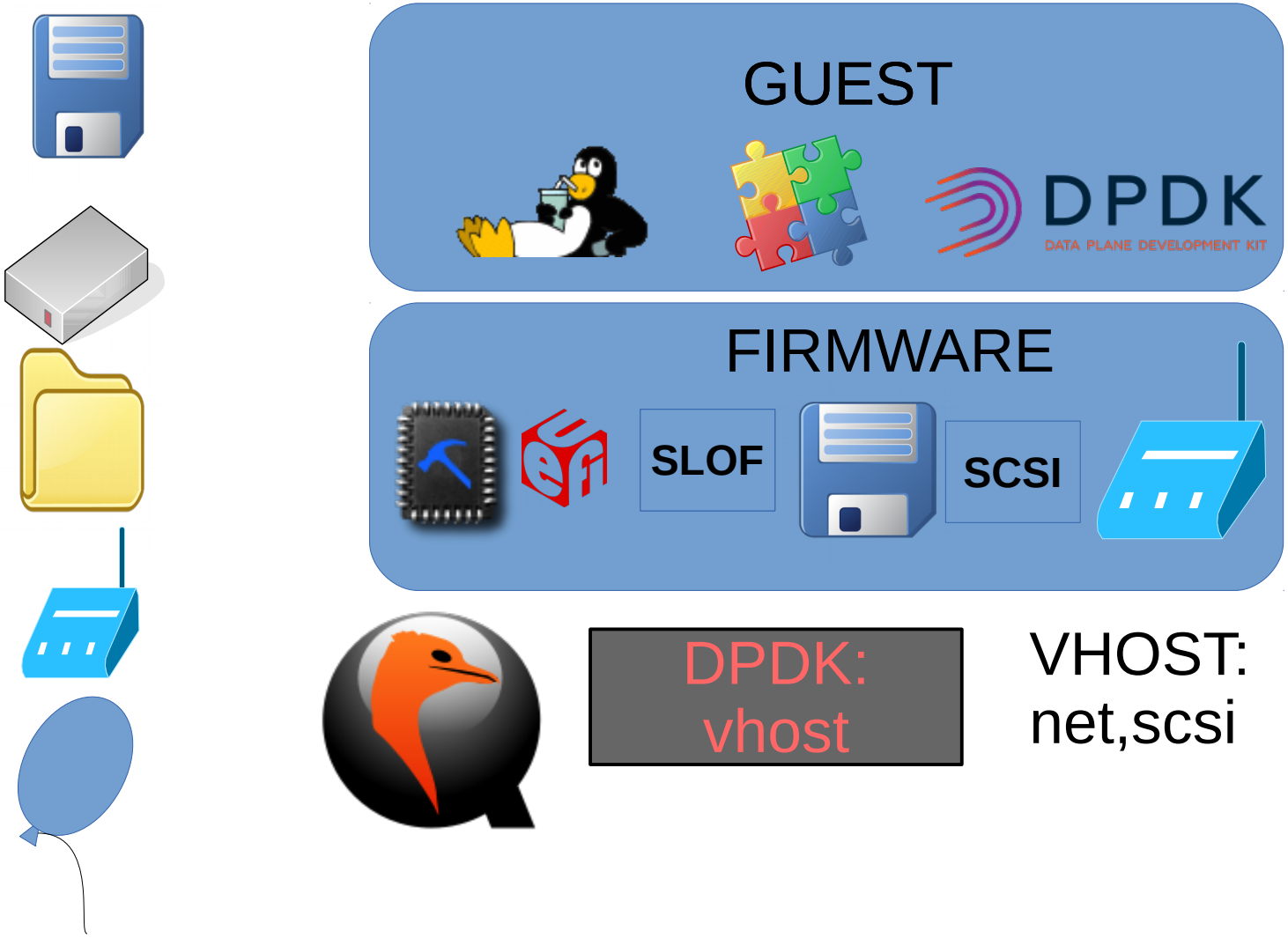
Uses material from https://lwn.net/Kernel/LDD3/
Gcompris, tuxpaint, childplay

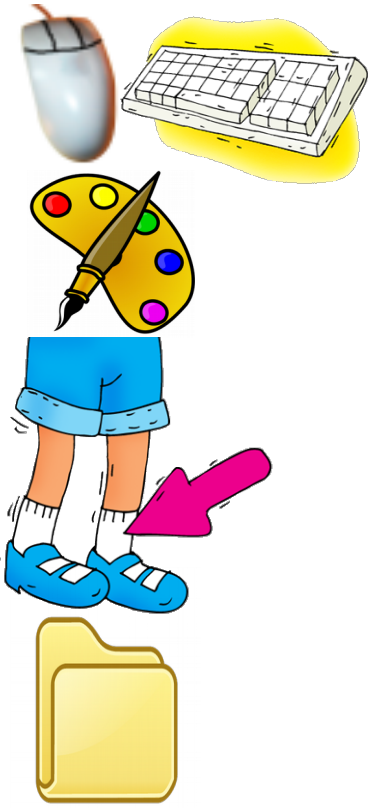
1.0 - towards an OASIS standard



OASIS

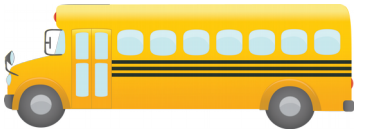
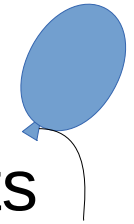
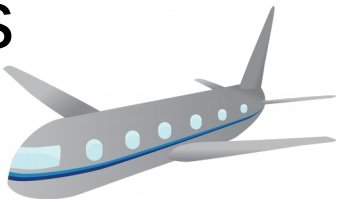
Standartization

- Next: v1.1
- Devices
  - Virtio-input
  - Virtio-gpu
  - Virtio-vsock
  - Virtio-9p

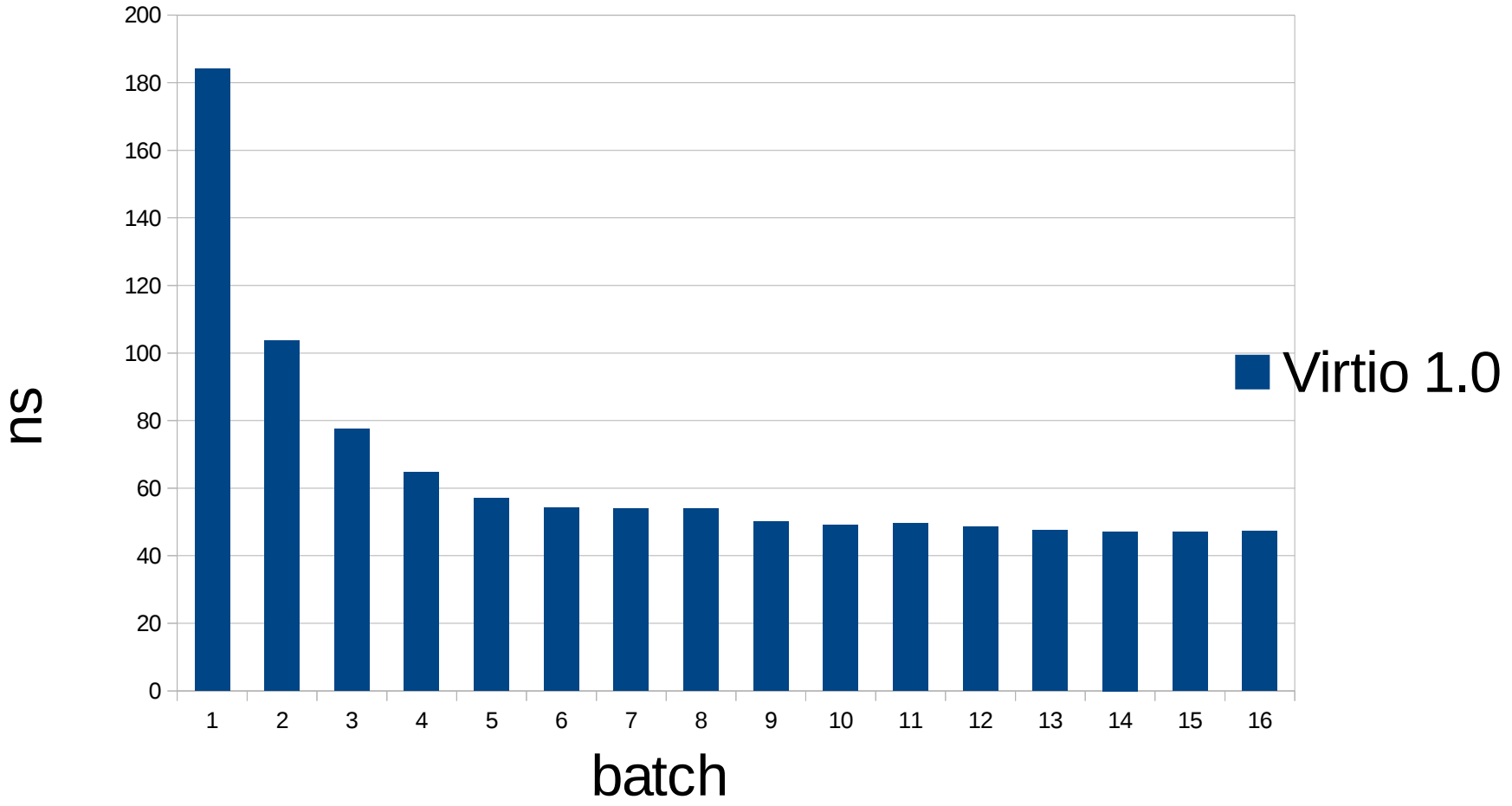


- Transport
  - IOMMU / Guest PMD

What to expect?

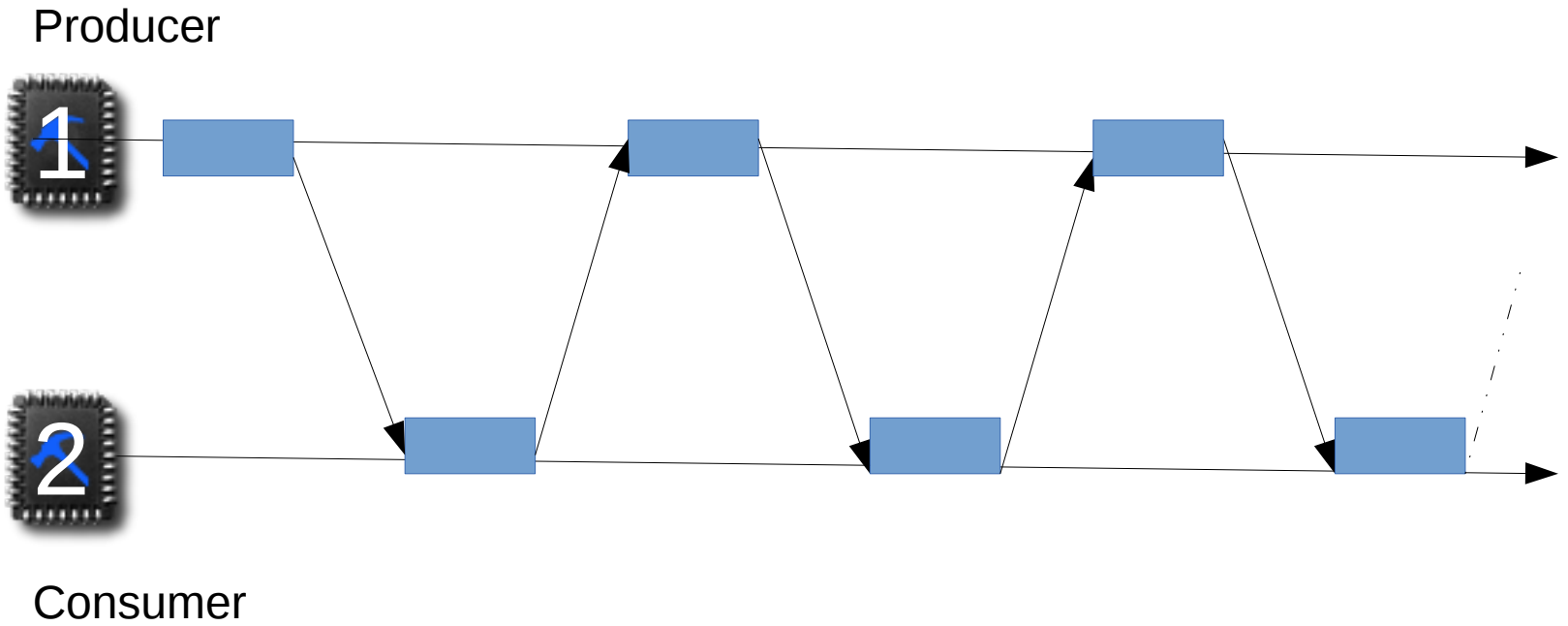
- Devices
  - Virtio-crypto 
  - Virtio-pstore 
  - Virtio-sdm 
  - Virtio-peer 
- Transport
  - Vhost-pci 
- Features
  - Balloon page hints 
- Enabling performance optimizations 

Request processing time



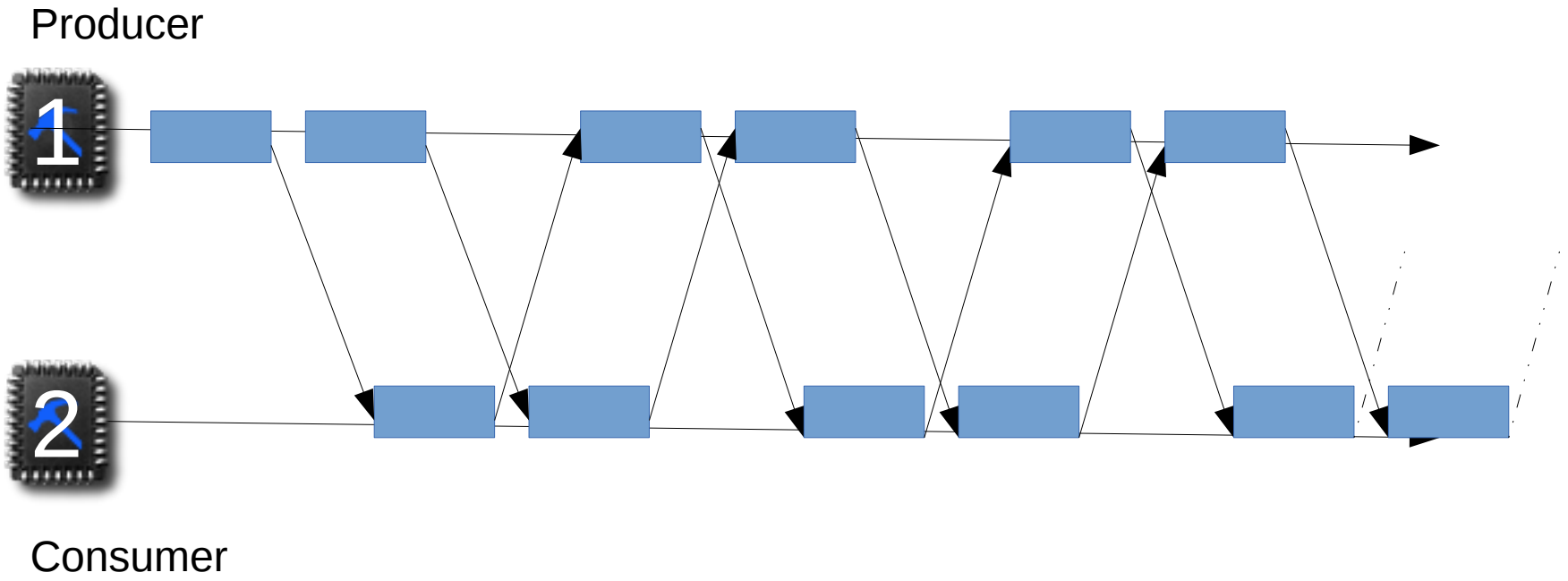
Why does batching help?

- batch=1



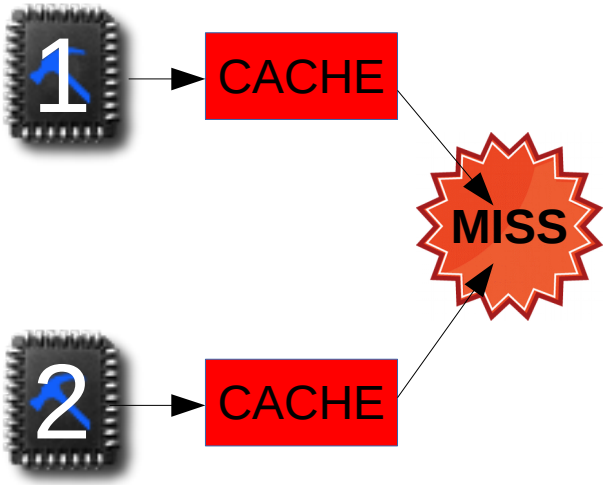
Why does batching help?

- batch=2: pipelining increases throughput

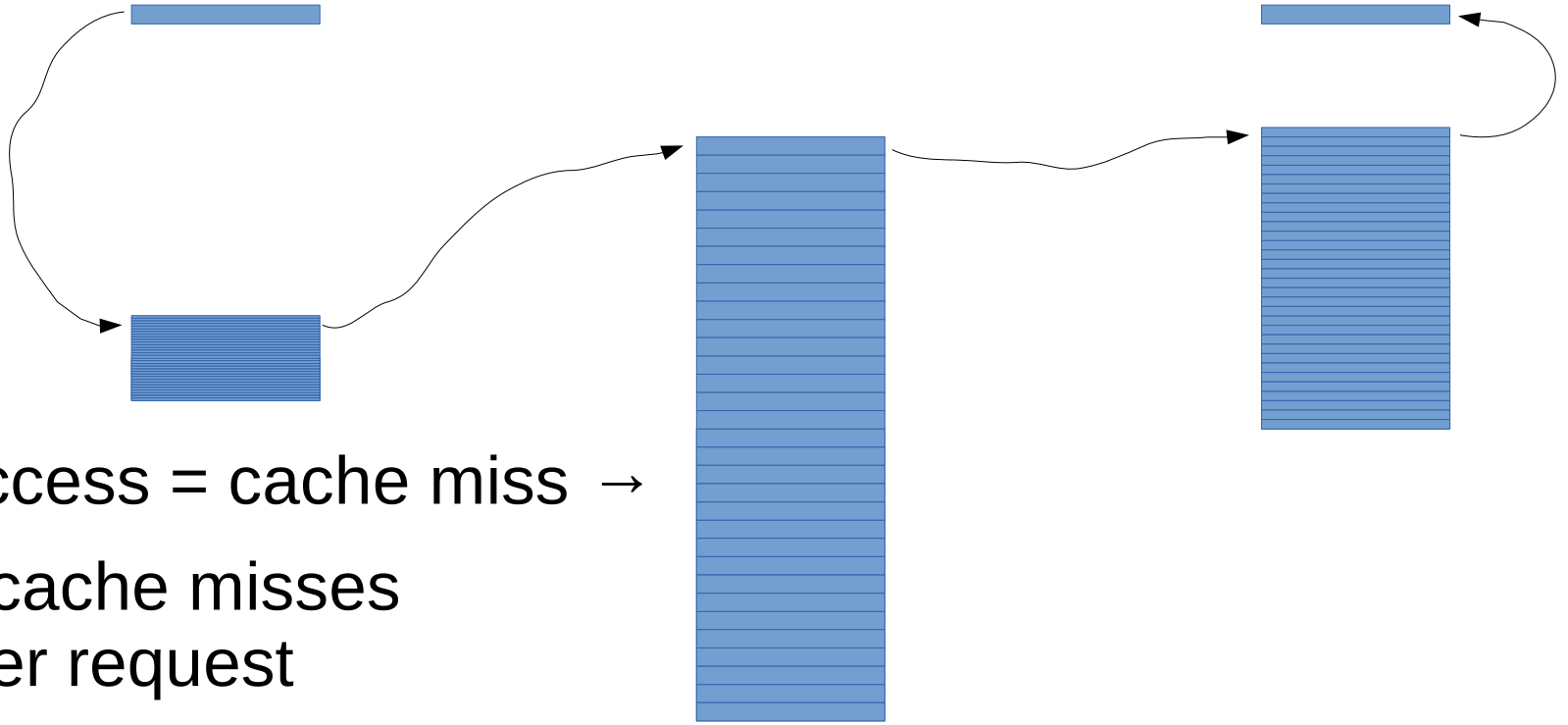


CPU caching

- Communicating through a shared memory location can cause cache misses.
- Number of these impacts latency.



Virtio 1.0: no batching

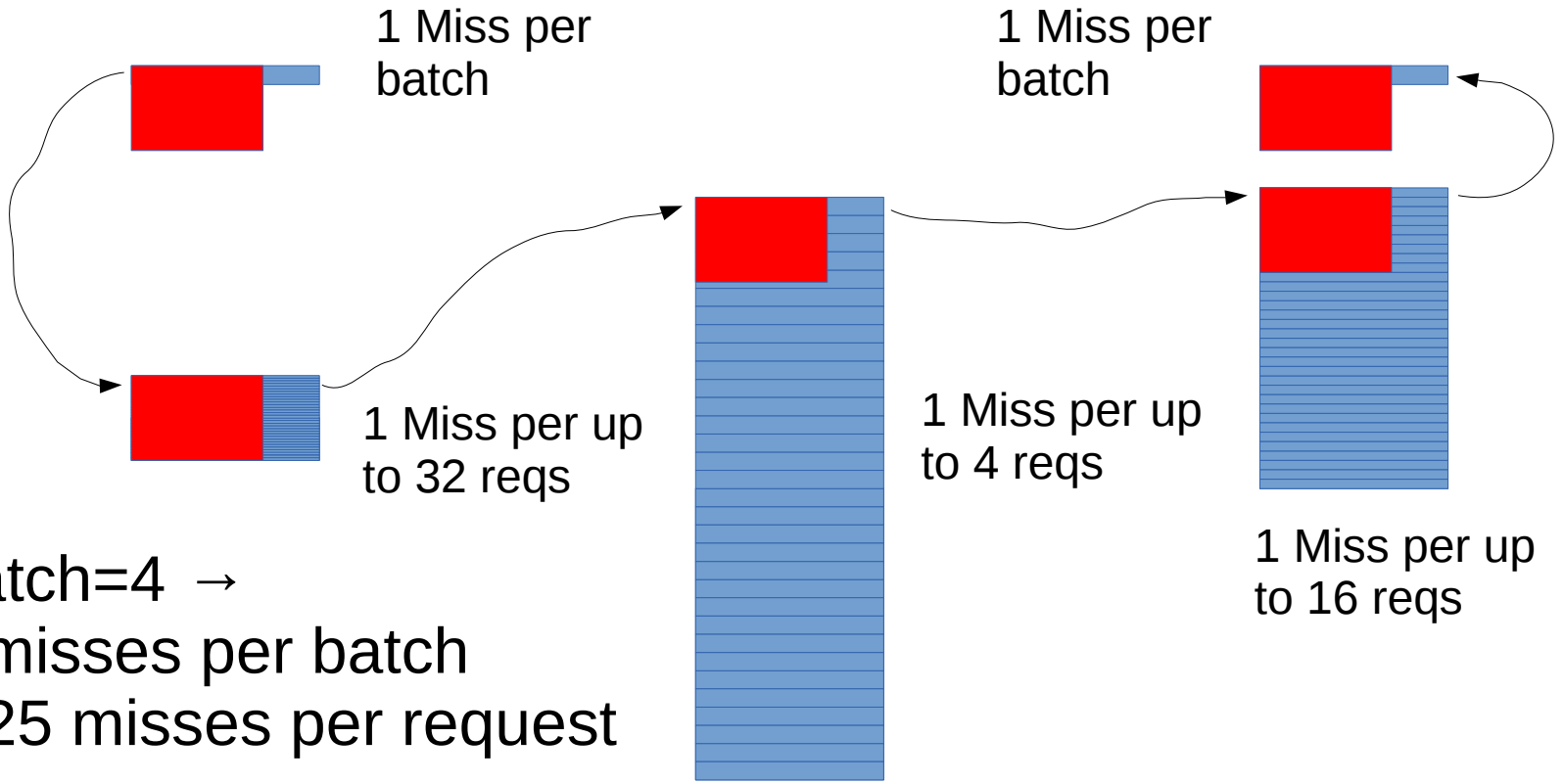


- Access = cache miss →

  5 cache misses
  per request

CPU caching

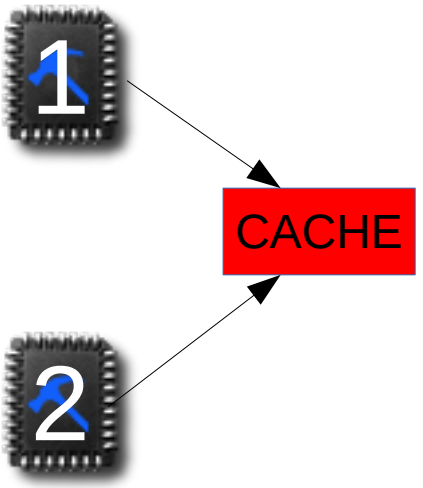
- Virtio 1.0 queue layout: batching



- Batch=4 →
  5 misses per batch
  1.25 misses per request

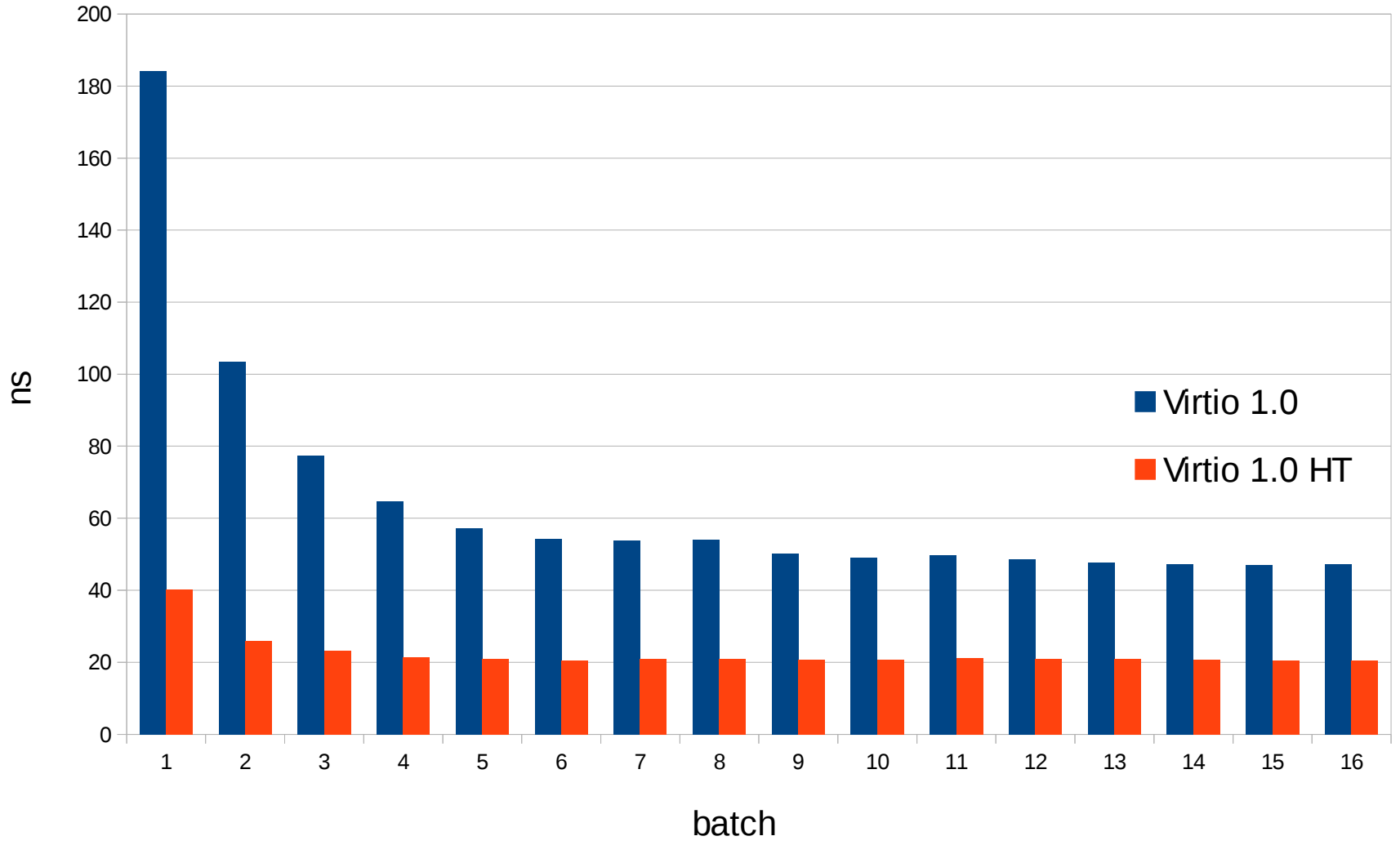
Estimating caching effects: Hyperthreading

- Shared cache
- Pipelining effects still in force



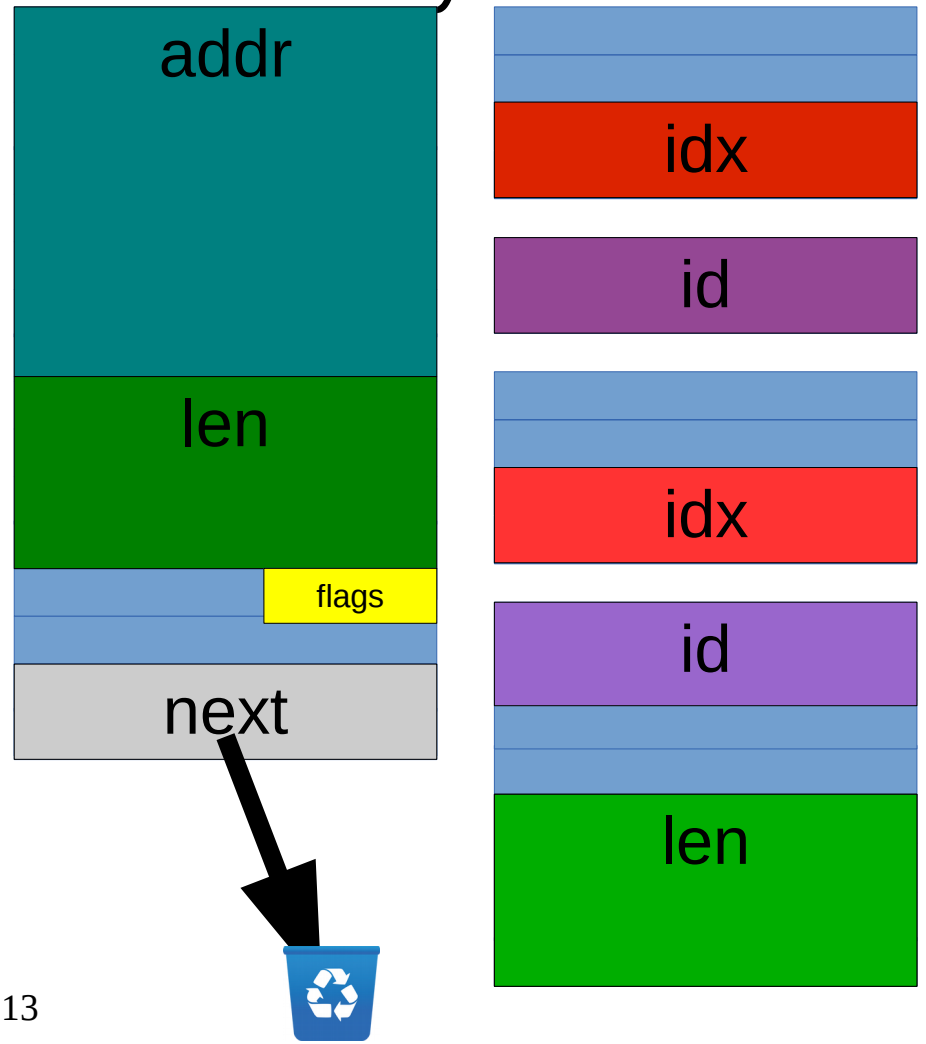
- Not a clean experiment: HTs can conflict on CPU
- Still interesting

Request processing: comparison

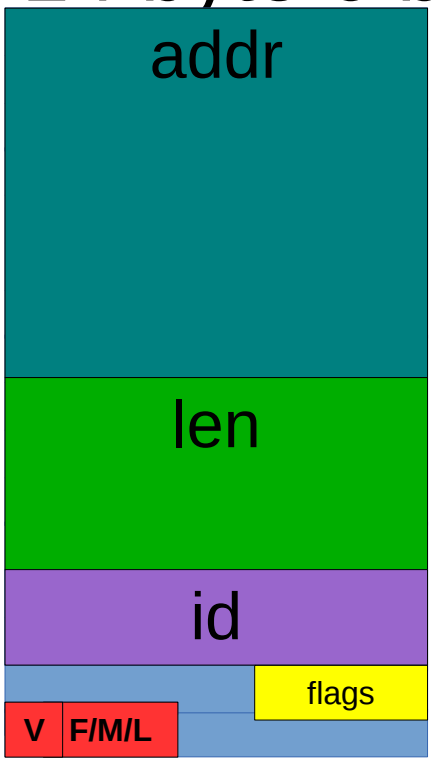


Virtio 1.0 vs 1.1 (partial)

- 1.0: 26 byte 3 bit

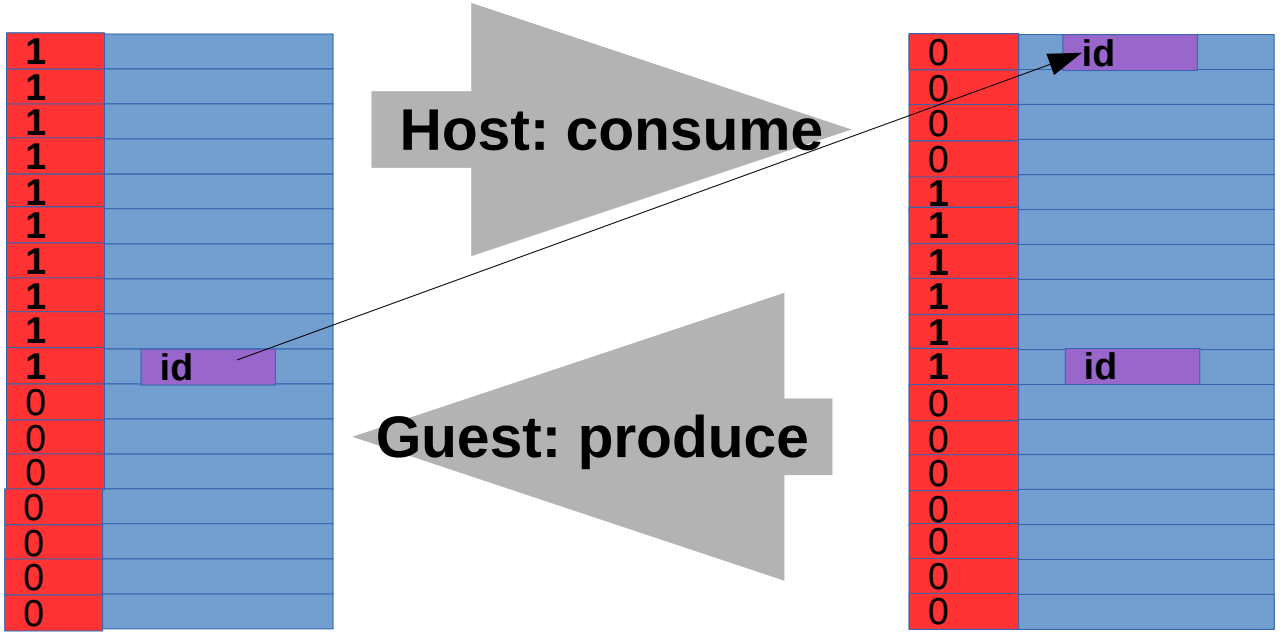


- 1.1: 14 byte 6 bit



Virtio 1.1: read/write descriptors

- Guest: produced 9
- Host: consumed 4



- V=0 – OK for guest to produce
- V=1 – OK for host to consume

Host: pseudo code (in-order)

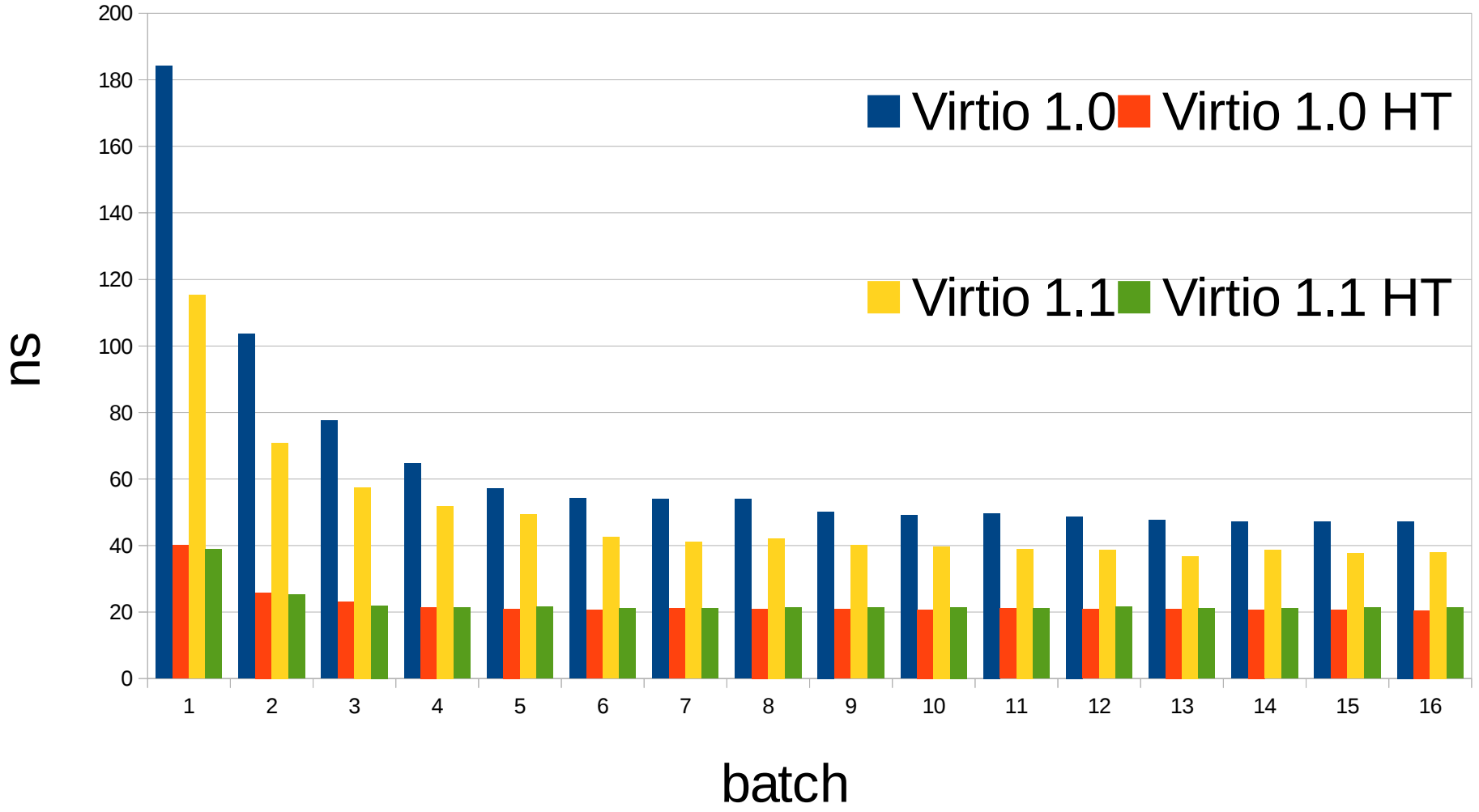
```
while(!desc[idx].v)      ← miss?
    relax();
process(&desc[idx]);
desc[idx].v = 0;         ← miss?
Idx = (idx + 1) % size;
```

- Write access can trigger miss

CPU caching

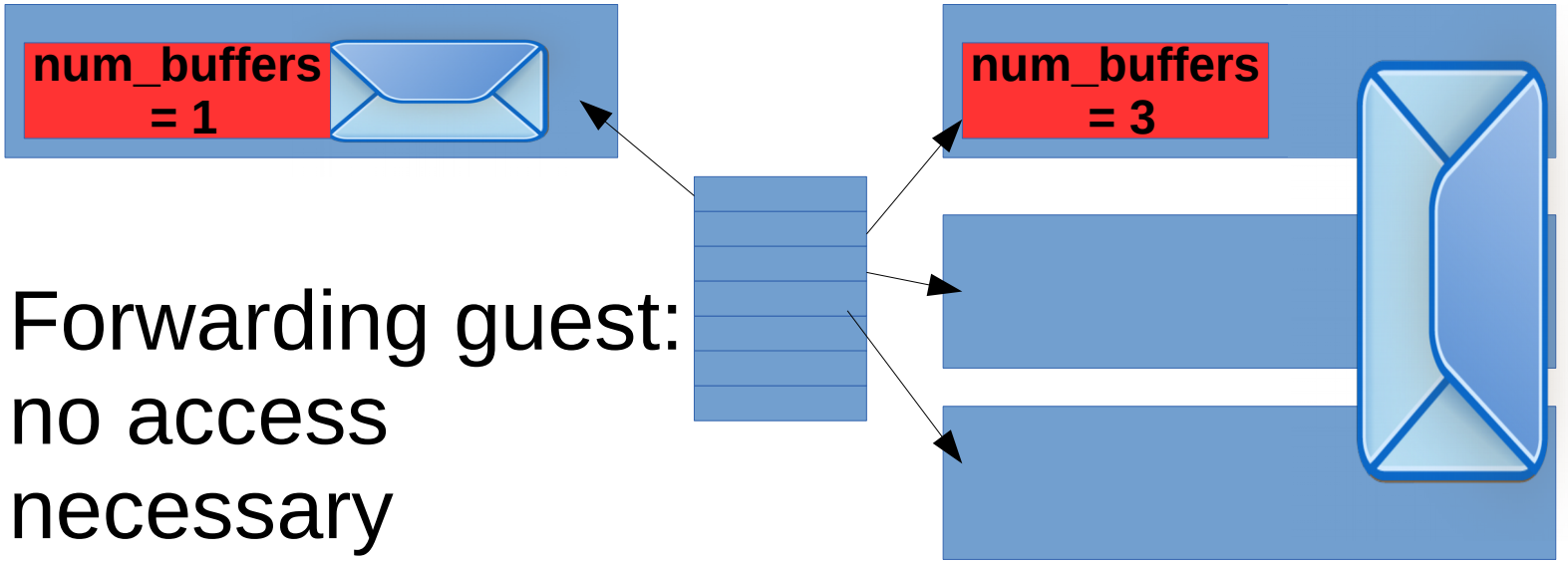
- Both host and guest incur misses on access
- No batching: 2 to 4 misses per descriptor
- Batch=4:
  2 to 4 misses per batch
  4 descriptors per cache line →
  0.5 to 1 misses per descriptor
- Better than virtio 1.0 even in the worst case

Request processing: comparison



Virtio 1.0: mergeable buffers

- Small packet
- Large packet



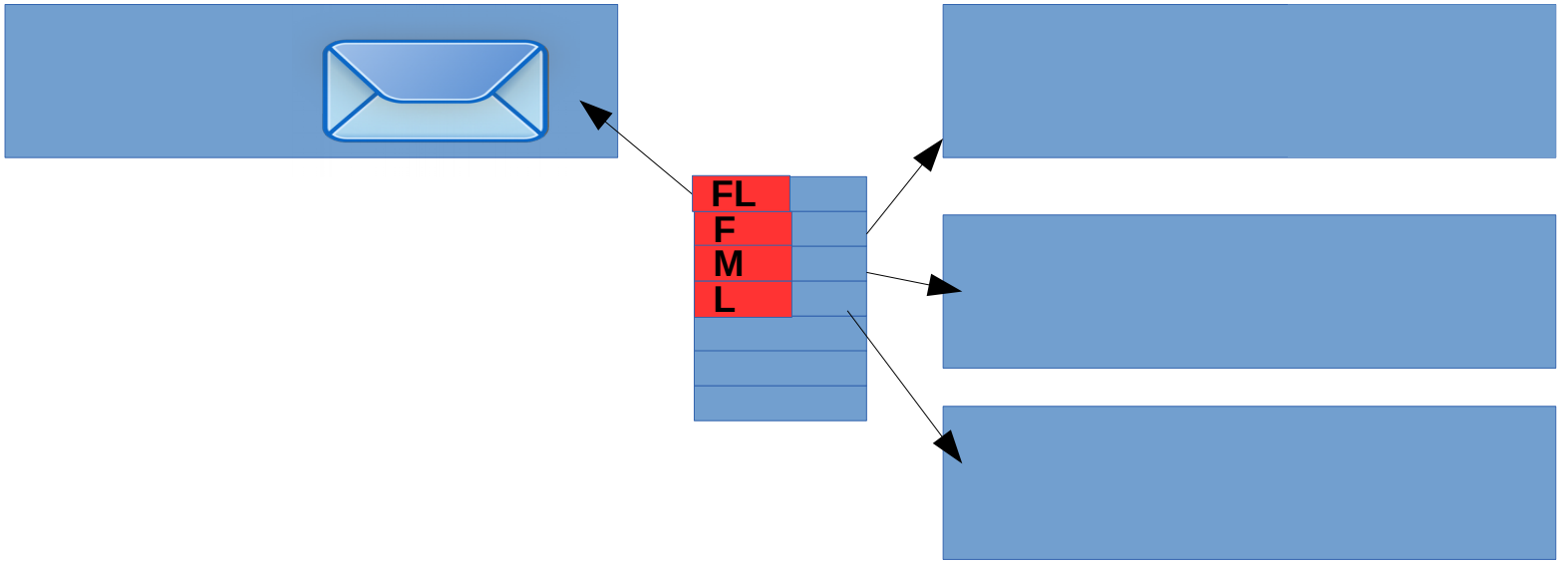
- Forwarding guest: no access necessary

```
-               seg_num = header->num_buffers;
+              //seg_num = header->num_buffers;
```

- Small packet throughput +15% (Andrew Theurer)

Virtio 1.1: potential gains

- Small packet
- Large packet

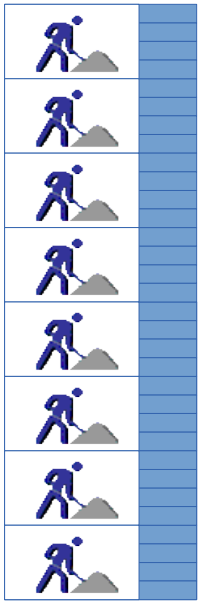


- seg_num = header->num_buffers;
+ while (!(desc.fml & L)) {...}

- Avoid 1 miss per packet. Performance - TBD

Parallel ring processing?

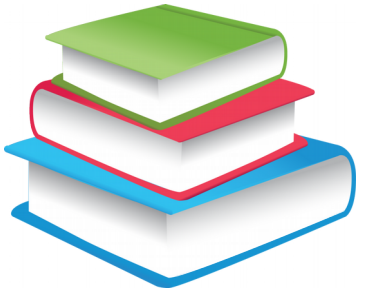
- Virtio 1.0: workers contend on idx cache line
- Virtio 1.1: can host or guest parallelize?
- If order does not matter
  (e.g. network TX completion):



- Each worker polls and handles its own descriptors

IO kick / interrupt mitigation

- event index mechanism
  - Similar to avail/used idx
  - Miss when enabling interrupts/IO
- flags mechanism
  - keep interrupts/IO enabled under light load
- first/middle/last to get interrupt per batch
  - Linux: batching using skb->xmit_more



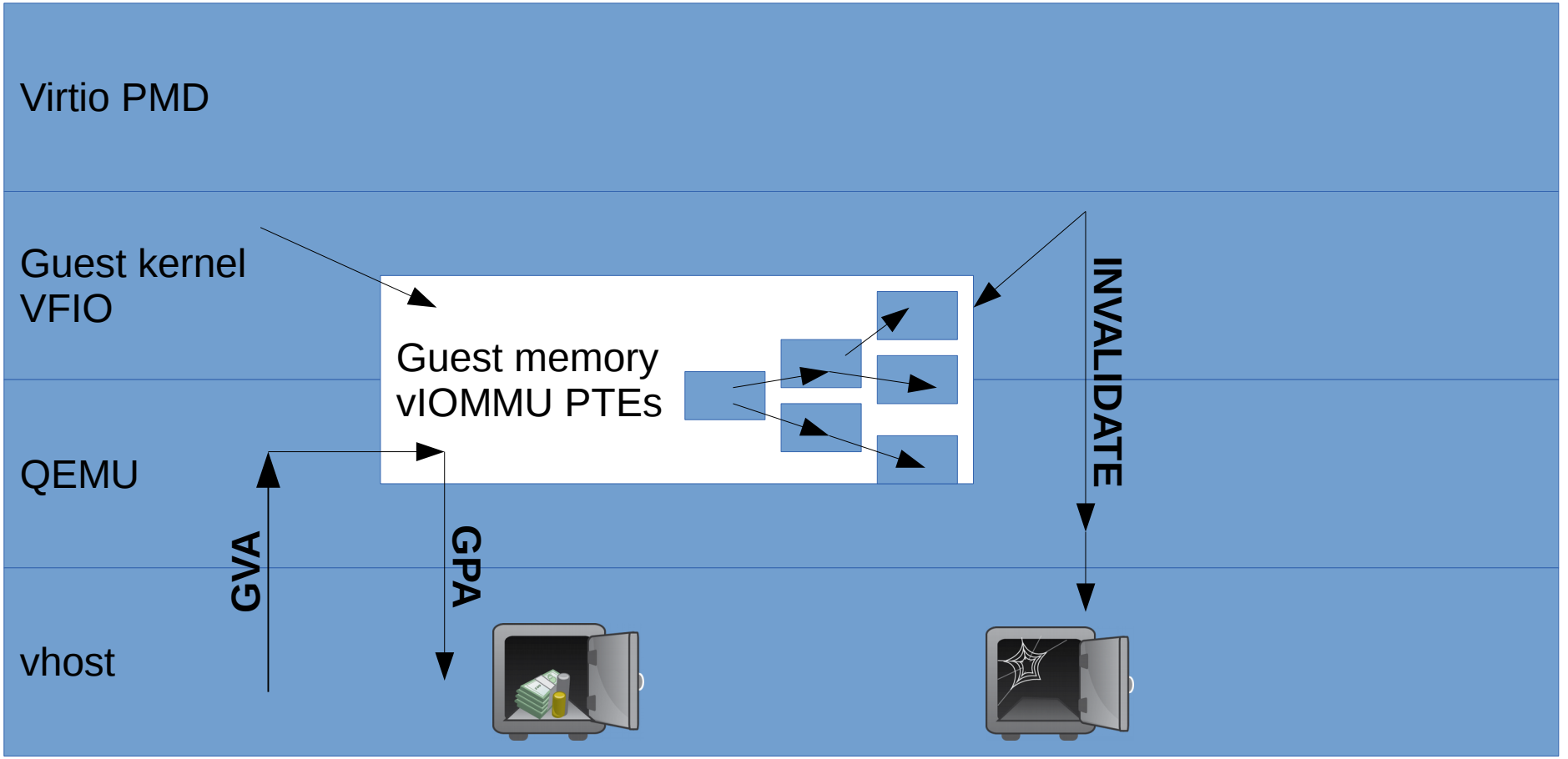
Research

- Rings are RW
  - security issue?
  - Virtio-peer proposal?
- Test on different CPUs
  - AMD (MOESI)
  - ARM
  - Power
- Integrate in existing virtio implementations

VIRTIO_F_IOMMU_PLATFORM

- Legacy: virtio bypasses the vIOMMU if any
  - Host can access anywhere in Guest memory
  - Good for performance, bad for security
- New: Host obeys the platform vIOMMU rules
- Guest will program the IOMMU for the device
- Legacy guests enabling IOMMU will fail 😟
  - Luckily not the default on KVM/x86 🥲
- Allows safe userspace drivers within guest

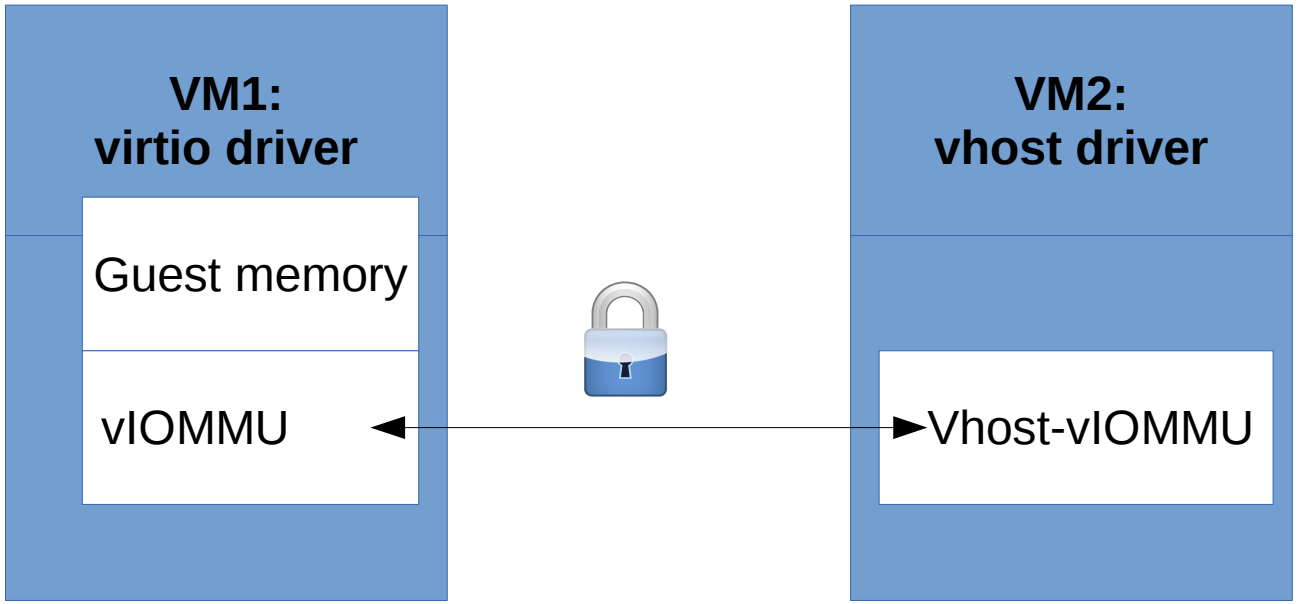
Virtio PMD: static vIOMMU map



- Cost: up to 4-5% for small packets. Tuning TBD
- Vhost-user can do the same

Future use-cases for vIOMMU

- Vhost-pci: VM2 can access all of VM1 memory



- Vhost-vIOMMU can limit VM2 access to VM1

Wild ideas

- Apic programming: about 20% of exits
  - Virtio-apic might help coalesce with host polling?
- Idle – kvm already doing some polling
  - Virtio-idle and combine with vhost polling?
- Kgt – write-protect kernel memory in EPT
  - Extend virtio-ballon page hints?

Implementation projects

- Indirect descriptors – extra indirection
  - when not to use?
- Vhost polling
  - Scalability with overcommit – better integration with the scheduler?
- Error recovery
  - Host errors: restart backend transparently
  - Guest errors: guest to reset device

Contributing

- Implementation
  - virtualization@lists.linux-foundation.org
  - qemu-devel@nongnu.org
  - … if in doubt – copy more
- Spec (must copy on interface changes)
  - virtio-dev@lists.oasis-open.org
- Driving spec changes
  - Report: virtio-comment@lists.oasis-open.org
  - https://issues.oasis-open.org/browse/VIRTIO

Summary

- Virtio 1.1 is shaping up to be a big release
  - Performance
  - Security
  - Features
- Join the fun
  - Spec is open: 9 active contributors / 7 companies
  - Implementations are open > 60 active contributors in the last year