KVM in an HPC Cloud
by Conrad Wood

Definition HPC Cloud:

- Can accommodate any “real” network configuration
- Is at least as fast as a common physical networks
- Is highly-available (feature of a cloud)
- “Real” services also available as HPC Services
- “Behaves” like several “real” datacenters

→ KVMs unique Flexibility allows this

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The Cornerstones

- The storage: fast and reliable (consistent)
- The network layer: fast, multi-tenant, filterable
- CPUs: mostly to support the above, a “visionary” outlook at the end

→ We discuss network and storage and their relation to CPU cycles

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I. The Storage

- Options: ZFS, Netapp, Gluster and others...
- Non-Integration: consistency on snapshot
- Providing a backup without stopping the VM:
  - Caches need to be flushed
  - Blocks written in the right order (journals/write-barriers)
- Mirroring with DM/ZFS to provide live-migration

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Storage Consistency

- In a cloud, access to the guest-os is limited to VM-Owner (not cloud-administrators)
- Backups have to be taken on-line
- Most snapshotting solutions require long delays in stopping the machine or slow down with each snapshot

→ a snapshot should be synchronized to a write-barrier

Waiting for the elevator...

- Data travels by elevators on guest, on host, on storage system
- Only the storage system knows how to order blocks
- Other elevators increase latency and have little benefit.

→ Guests need to be modified to 'detect' virtual I/O and disable elevators. A common indicator is needed

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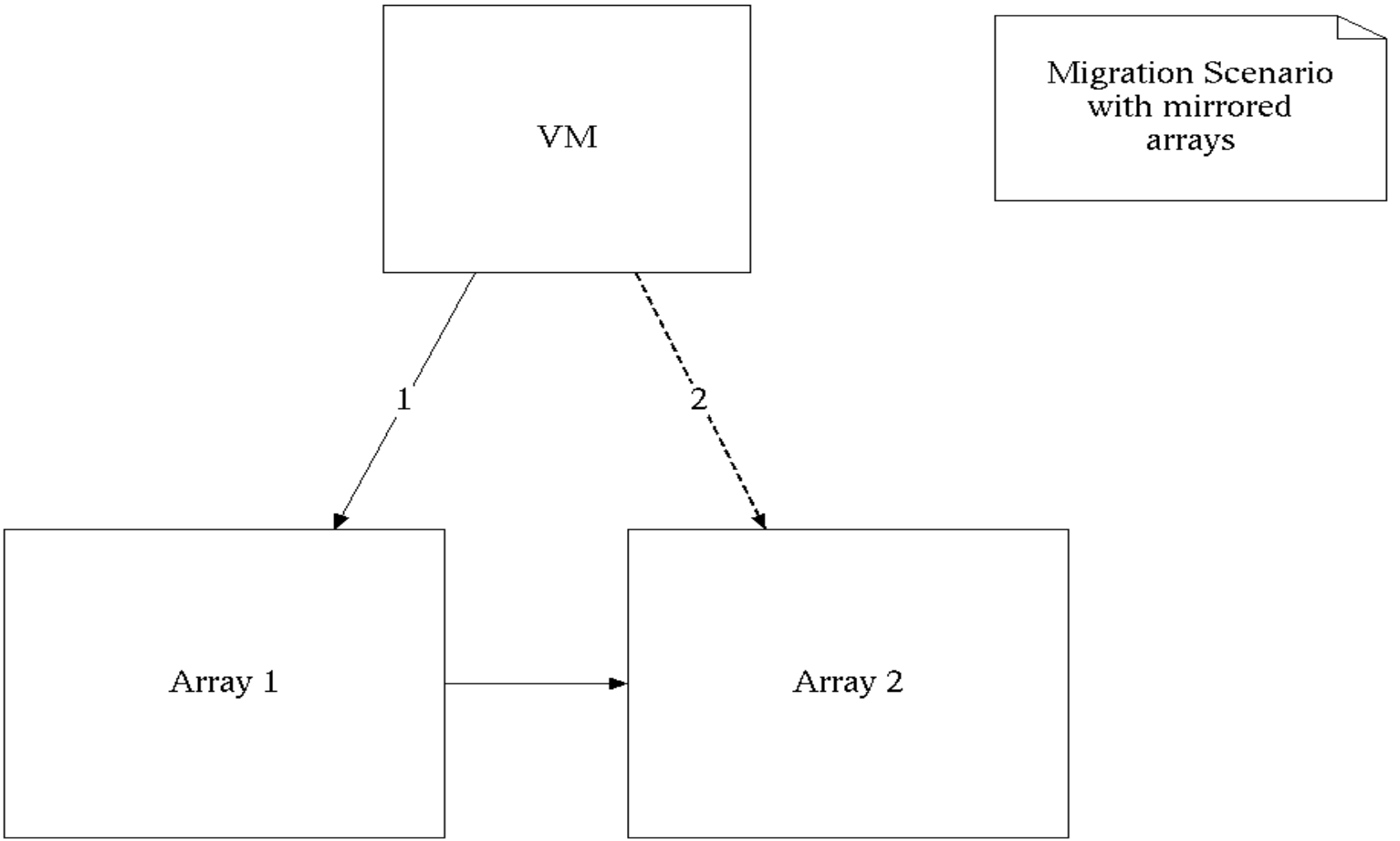
Interrupts & DMA

- Side effect of “elevating”: increase block I/O sizes
- Each interrupt is costly
- Block-drivers, e.g. Virtio, may indicate larger block-sizes to the guest
- Worse: switching memory contexts (MMU)
  (IOMMU has limited effect)

Replication

- VM-Migration: mesh-like storage access
- Mirroring helps with storage-migration
- Snapshot required to be part of the block-layer

Replication



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II. Networking

- Very recent Hardware includes options for multi-tenant / multi-VM:
  - SR-IOV (exposed pci-cards)
  - VTAG (double-tagging traffic)

- Missing:
  - Live-migration
  - Filterable traffic

- Others: e.g. vlan-in-vlan, IP-tunnelling

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Networking Software

- Current Network software, e.g.
  - OpenVSwitch (userland)
  - Linux Bridging
  - IP-over-IP

  can not perform as well due to extensive checks.

  → The VM traffic needs to bypass as much as possible as early as possible

Vhost modifications

- Reduce amounts of packets by suggesting a 64k MTU to the guest
- Add routing information to the sk_buf and deliver
- it straight out to the physical interface (bypassing tun/tap, bridging code etc..)
- Disable CRC/Seg. hardware offloading for speed
- Disjunct management of routing information
- Multi-thread vhost
  = more than 7Gbit/s per TCP Stream
  → Multi-Threading on multi-cores...

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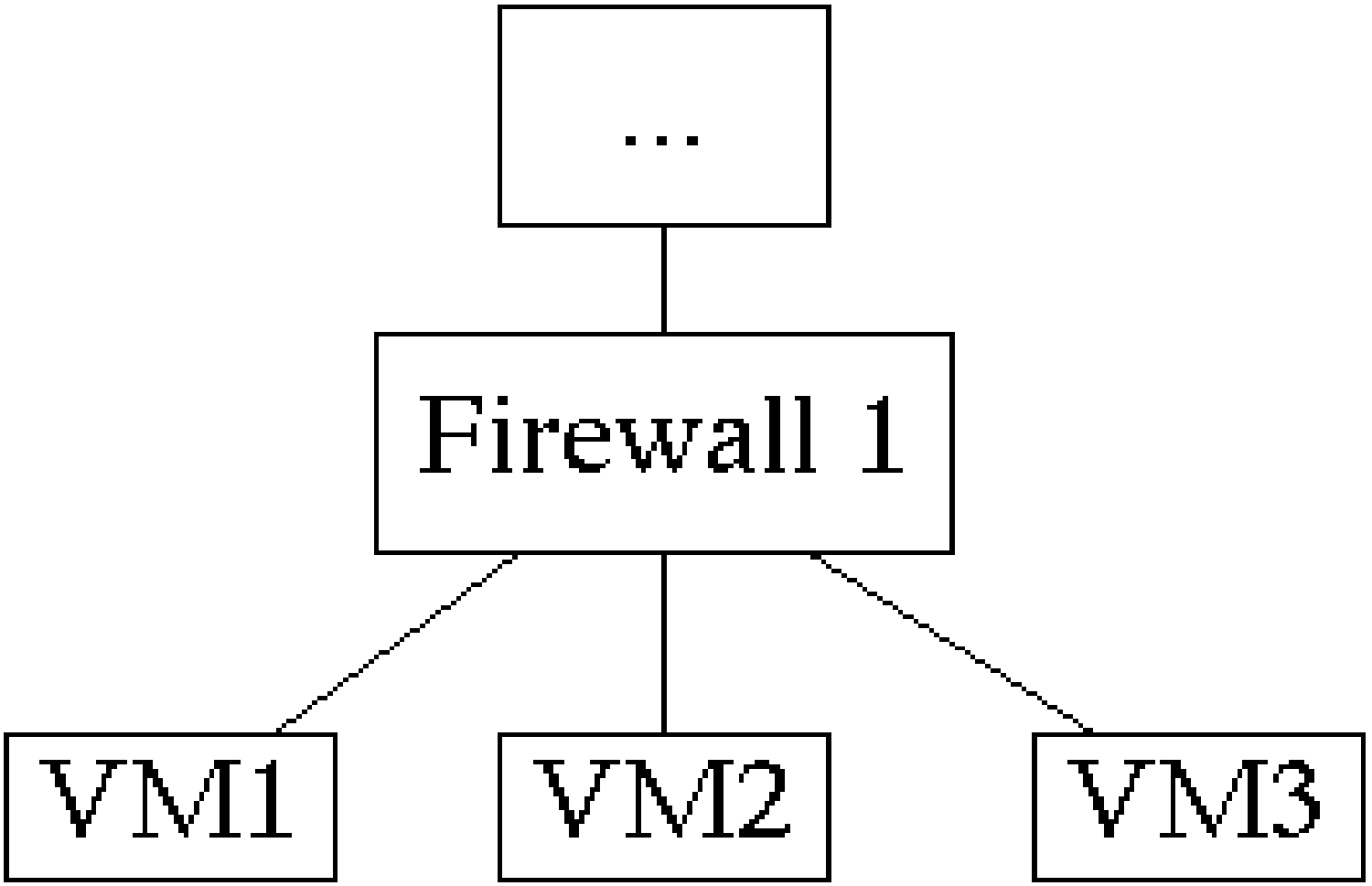
Multi-Threading Network issues

- Multi-thread = better throughput
- Possible starvation of vital number-crunching tasks
  - 'adaptive' pinning of KVM user-processes to CPUs
  - VHost threads follow user-processes (self-regulating effect)
- Sender and receiver must match
  = maintain max. performance over time

Advanced Networking

- Given the speed of a single VM, no IP-stack by itself can deliver faster than that
- Services dealing with traffic for multiple VMs need to be distributed in the same manner as the VMs
- For example, traffic inspection for firewalls need to be handled by the same code, in the same core as the VHost processes
- VHost modified to utilise iptables' connection tracking API to provide this

Distributed Traffic #1 (this...)



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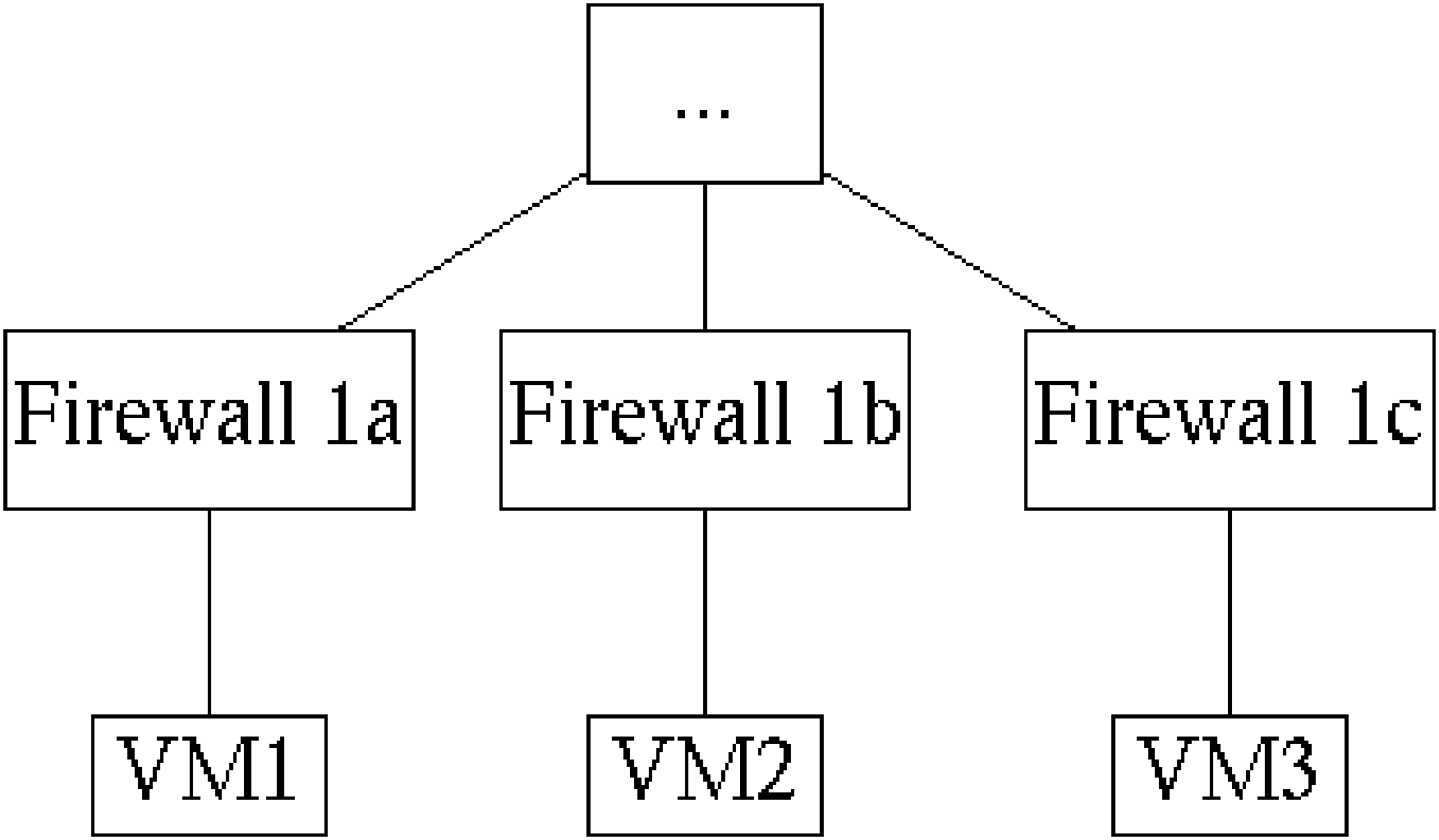
Distributed Traffic #2 (...becomes)



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Upstream commitment:

- Results in our environment show huge speed improvements (1.2 Gbit/s → 7Gbit/s !)
- Introduction of a “VHost direct routing API”
- VHost direct routing API to allow for the addition of new high-speed networking modes with ease

III. High-Availability

- Any changes to devices need to be performed on-line
- PCI-HotPlug: works as expected
- HotPlug: RAM & CPU requires support in guestOS, BIOS, QEMU and KVM

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CPU Hotplug

- Any changes to devices need to be performed on-line
- PCI-Hotplug: works as expected
- HotPlug: RAM/Memory/CPU requires support in guestOS, BIOS, QEMU and KVM
- The future: KVM-native-tool ?

CPUs (a vision)

- Given current network latency improvements, it becomes feasible to start scheduling work across high-speed links (e.g. Infiniband)
- Using continuous live-migration to keep ram in-sync via RDMA (40GigE/Infiniband)
- Overhead of slow RAM vs. more Cores
- Allows for VMs with more Cores than one physical node

Questions & Answers

Thank you for listening. - Profitbricks

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Questions ?

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hardware...

- Hardware can reduce the overhead of the software stack
- Current Status: too immature and not well enough integrated for a cloud environment
- Vendors give misleading information

Hardware offloading...

The cloud layer – offloading vs. flexible data movement and separation

- SR-IOV cross-datacenter still needs software encapsulation

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CPU...

Ideally, each VM should receive deterministic CPU slices.

KVM lacks CPU-slicing support.

Partial success with core-allocation via host-kernel

Virt-io-host also needs to be sliced.

CPU...

Each VM receives a dedicated 'partition' of the Intel/AMD hardware.

All services ought to remain within that partition

(VHost / non-virtualised drivers)

Not-used cores may be switched off at run-times

Storage...

Difficulty finding storage that meeds cloud needs

(block devices) mention gluster/sheepdog/zfs

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Network...

Status of Current openvswitch and -friends

Speed Linux Network bridges – limiting factor

Multi-core scaling

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Network...

Loadbalancer / Firewall

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