Towards a Lightweight RDMA Para-Virtualization for HPC

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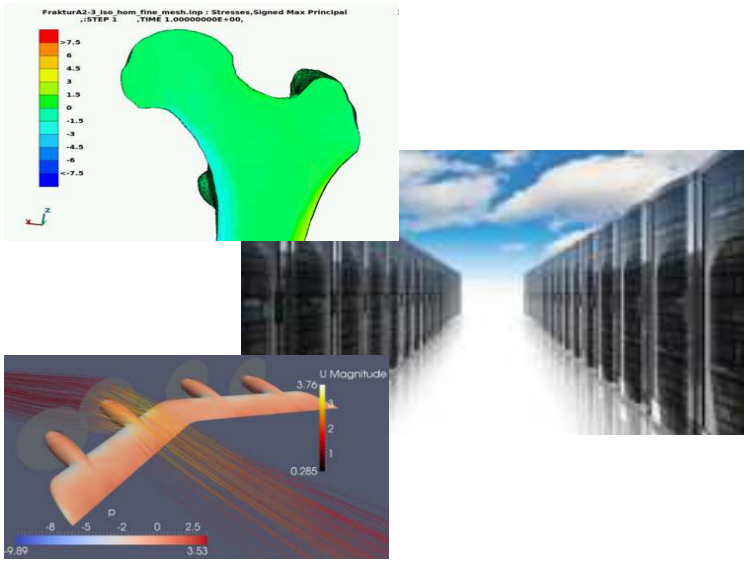
Background

- Virtualized HPC and HPC Cloud become more popular and requires lightweight solutions (unikernel-like OS)
  - Cloud: Flexibility, Scalability, Reliability, …
  - HPC: Power and extreme speed of computation and data analysis
- Challenging workloads regarding latency throughput, may benefit from RDMA
  - RDMA virtualization is required



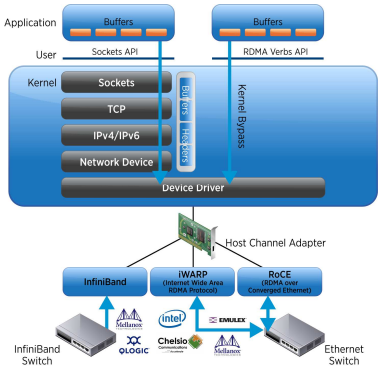
Why not SR-IOV ?

RDMA virtualization: State of the art

- **Control Path:** RDMA verbs translated to host
- **Data Path:** RDMA memory mapped to backend driver and RDMA HCA

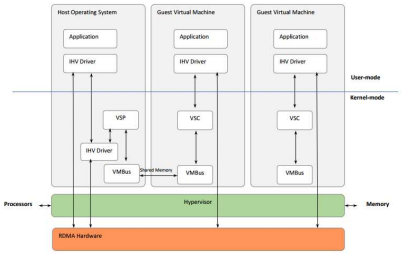
vRDMA

- Solution from VMWare
- Support RDMA API
- Supports ESXi platform
- Not open source
- Public results



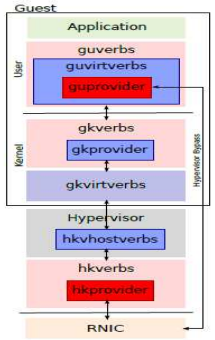
Endure

- Solution from Microsoft
- Support RDMA API
- Support Azure cloud and Windows/Linux guest
- Not open source
- No public results



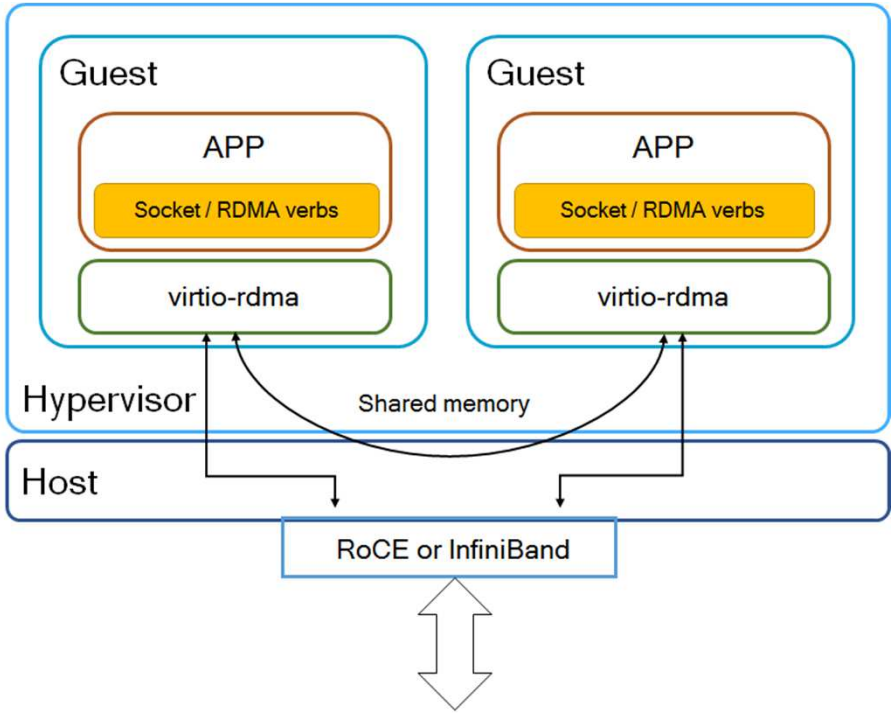
HyV

- Solution from IBM
- Support RDMA API
- Support Linux guest/host
- hypercall for control path
- Open source
- Public results



virtio-rdma: Design Overview

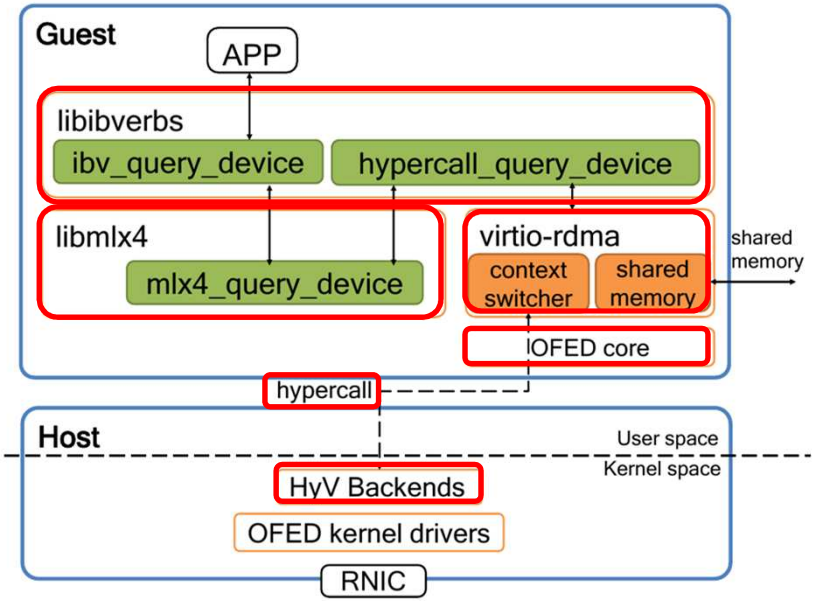
- High bandwidth, low latency network I/O
- Lightweight, flexible, and portable
- Targeting at unikernel-like OS, **OSv**:
  - Fast, lightweight, less overhead
  - Bridge Cloud and HPC
- Support socket and RDMA verbs API
- Shared memory for the intra-host communication
- Support RoCE* and InfiniBand



*RoCE: RDMA over Converged Ethernet

virtio-rdma: Control Path

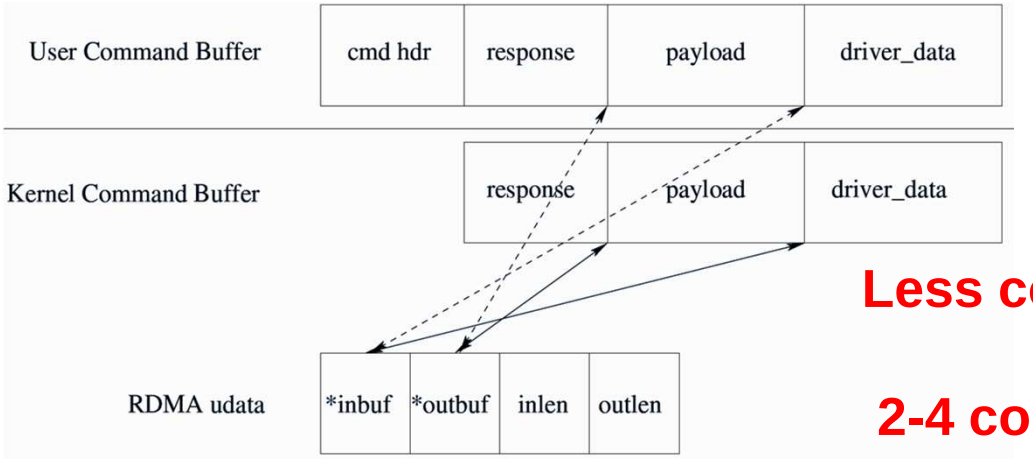
- Re-use the HyV backend driver
  - Ported to a newer Linux kernel
- Guest side implementation on **Osv**
  - Re-implemented frontend driver, hypercall
  - Streamlined/minimized OFED support
- Data path: RDMA memory is mapped directly from guest to host and HCA
  - Completion Queue, Queue Pairs, and Work Requests



Lightweight, flexible and portable

virtio-rdma: Context Switch

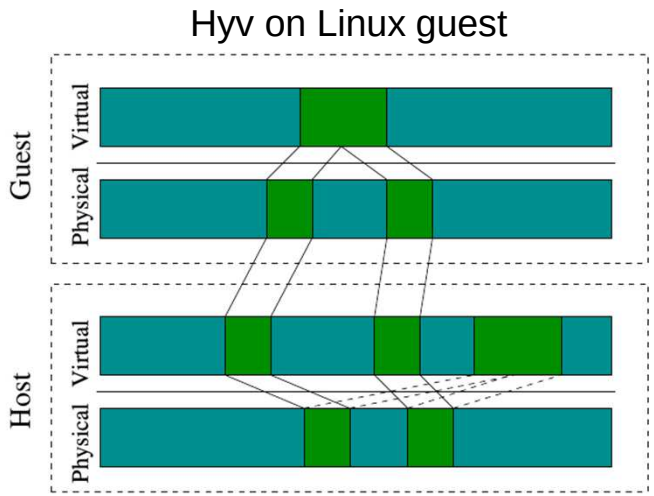
- Context switches are reduced
  - OSv runs application in the same privilege level, single address space
  - No boundary of user/kernel space
  - Less calls to external libraries
- minimum number of memory copy
  - only a few memory copies are needed for OFED core data structure

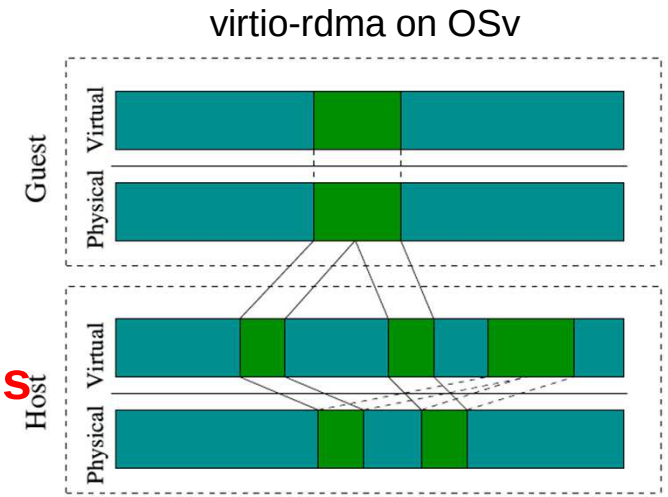


Less context switch
&
2-4 copies avoided per call

virtio-rdma: Memory Mapping

- Guest allocate contiguous memory in virtual address space
- frontend driver remap the virtual address to guest physical address with chunks
  - HyV needs to take care of the non-contiguous physical address and the offset in the page
  - OSv always tries to allocate contiguous mem.
  - virtio-rdma only cares for the offset
- Backend driver remaps the chunks into host physical address



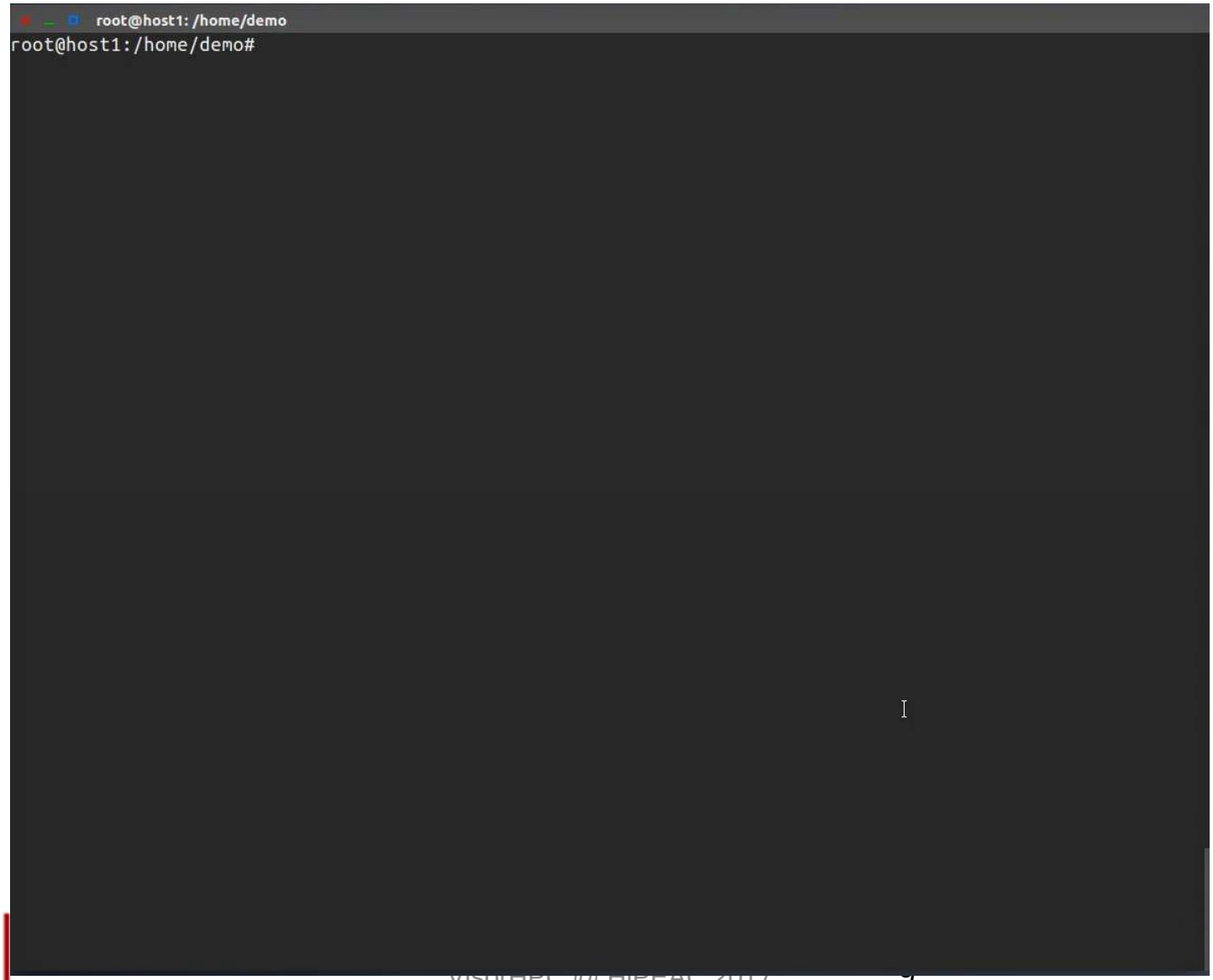


Efficiency on address translation:
Saved N-3 translation
(N >=3: num of pages)

virtio-rdma: Future Work

- Shared memory
  - Based on IVSHMEM
  - Protocol switch in RDMA verbs API
  - Communication buffers, e.g. user memory, shared to the VMs of same host
  - Update RDMA memory regions directly, e.g. Completion Queue
- Socket API support
  - forward to use RDMA and shared memory communications
  - re-implement rsocket or libvma onto OSv
  - no modification to the user application is needed
- HPC Integration
  - Setup the necessary environment via Torque when VM starts

Demo



Conclusion

- Redesigned and Implemented the new virtio-rdma driver on OSv
  - Compatible with HyV backend driver, i.e. same hypercall
  - Fewer OFED dependencies and fewer context switches
  - Simpler memory translation
  - Flexible and portable for other unikernel-like OS
- Streamlined OFED user libraries and core structures for OSv
- Reused the HyV backend driver and ported it to newer Linux kernel
- HPC Cloud enabled

Acknowledgement

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Thank you!