urDMA: A Remote Direct Memory Access verbs provider using DPDK

PATRICK MACARTHUR
UNIVERSITY OF NEW HAMPSHIRE
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Agenda

• Background
• Implementation
• Evaluation
• Summary
Background
Background: RDMA (Remote Direct Memory Access)

- Message-oriented
- “Zero-copy”: direct transfer between remote application virtual memory regions with no intermediate data copies (on the hosts)
  - Requires application to pre-register memory
- Kernel bypass: userspace application has direct access to network adapter
- Asynchronous: data transfers occur in parallel with application threads, using OpenFabrics Alliance (OFA) verbs API
- Transfer operations
  - SEND/RECV
  - RDMA WRITE: push data to remote memory region
  - RDMA READ: pull data from remote memory region
- Data structures: Queue Pair (QP), Completion Queue (CQ)
- Standards: InfiniBand, RoCE, iWARP
urdma: Userspace Software RDMA

- Software emulation of RDMA using DPDK
- Goals
  - Low latency, high throughput
  - Run on commodity Ethernet NIC
  - Run unmodified verbs applications
  - Perform data transfers in userspace using DPDK
- Prior work: softiwarp/softroce
  - Perform data transfer in kernel space using kernel sockets
- Why urdma?
  - Ease of development, easy to use as a development vehicle for new RDMA features
  - Storage applications; integration with SPDK (Storage Performance Development Kit)
Implementation
urdma: Components

Multi-process application
- **urdma_kmod**: Loadable kernel module for RDMA CM support
- **urdmad**: DPDK primary process
- **urdma_prov**: User verbs provider library; applications run as DPDK secondary process
urdma: Protocol

- Implements iWARP DDP and RDMAP protocols
- Runs over UDP transport protocol
  - TRP (Trivial Reliability Protocol) as thin reliability shim
  - Avoid byte-stream nature and state machine of TCP
**urdma: Packet Processing**

- urdmad assigns each RDMA queue pair a hardware receive/transmit Ethernet queue
  - To allow verbs applications to access the NIC independently
- Ethernet NIC hardware filters used to separate packets into RX queues
  - Using **Flow Director** or **ntuple** filtering
  - urdmad forwards all unfiltered packets on each interface to kernel
  - For each established connection, packets filtered to specific receive queue—received directly by verbs application via urdma_prov
urtdma initialization issues: rte_eal_init()

- As a verbs provider library, we want DPDK to be invisible to the user application
  - We call rte_eal_init() in our own implementation
- Our provider code is only run if urdma kernel module loaded and urdmad master process started
- Specific issues with rte_eal_init()
  - Takes command-line arguments
    - We construct our own fake argument list
  - Changes CPU affinity of calling thread
    - We create a new thread and call rte_eal_init() from that thread
    - Tell rte_eal_init() not to create other lcores
- All verbs applications must run as the same user (not necessarily root)
urdma_prov: Data Transfer

- Data transfer done in background progress thread
  - Separates DPDK operations from application threads
  - Allows progress for RDMA READ and RDMA WRITE outside of verbs calls
  - Inter-thread communication done via ring queues
    - Enqueue one entry at a time
    - Dequeue entries in bulk
urdma_kmod: Connection Establishment

urdma_kmod must enable receive filter before first packet arrives
Evaluation
Performance Test Setup

2 pairs of systems with Ubuntu 16.10 with Linux 4.8.0-46-generic kernel, DPDK 16.07.2, PCIe generation 3

• urdma/softiwarp (Software Implementations)
  • Dual Intel Xeon ES-2630 v4 CPUs @ 2.20GHz
  • 64 GB DDR4 RAM
  • Intel XL710 40GbE NIC (firmware v5.05)

• Reference iWARP Hardware Implementation
  • Dual Intel Xeon E5 2609 CPUs
  • 64 GB DDR3 RAM
  • Chelsio T580-LP-CR Unified Wire Ethernet controller (firmware v0.271.9472)

• Applications used
  • perftest version 3.0+0.18.gb464d59-1
Perftest Latency: urdma vs. Chelsio iWARP NIC

urdma (Software)

Better

Worse

Hardware
Perftest Throughput: urdma vs. Chelsio iWARP NIC

urdma (Software)

Hardware

Better

Worse
Summary
Summary

• urdma
  • Software emulation of RDMA
  • Runs unmodified RDMA verbs applications
  • Performs all data transfer in userspace
  • No dependency on specific hardware
  • Achieves reasonable performance

• Future work
  • Zero copy sends?
  • Using urdma for NVMf traffic
  • Integration with emerging storage class memory technologies
Thanks!

Questions?

Patrick MacArthur <patrick@patrickmacarthur.net>
urdma download: https://github.com/zrlio/urdma