Lustre Networking
over
OpenFabrics

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The Lustre File System

- **Scalable**
  - Tens of thousands of clients / Petabytes of data
- **Reliable**
  - Deployed on production clusters
- **Fast**
  - Deliver 95% of hardware performance
- **Cost Effective**
  - Industry – standard platforms
  - Heterogeneous networks

LNET – the lustre networking API

- Network independent
- Message passing and RDMA
- Abstract scatter/gather network buffer descriptors
- Generic failure handling
- Routing over heterogeneous networks

LND - the lustre network driver

- Network specific
- Connection establishment
- Message Passing
- RDMA
- Failure handling

Supported Networks

- **TCP/IP**
- **Quadrics**
- **Myrinet**
- **Infiniband**
  - OpenIB gen1 / Mellanox Gold (thinly disguised TopSpin ☺)
  - Silverstorm
  - Voltaire
  - OpenFabrics
- **RapidArray (Cray XD1)**
- **Cray Portals (XT3)**

OpenFabrics API Calls used

- **CM**

  rdma_create_id
  rdma_destroy_id

  rdma_connect
  rdma_disconnect

  rdma_create_qp
  rdma_destroy_qp

  rdma_bind_addr
  rdma_resolve_addr
  rdma_resolve_route

  rdma_listen
  rdma_accept
  rdma_reject

- **VERBS**

  ib_alloc_pd
  ib_dealloc_pd

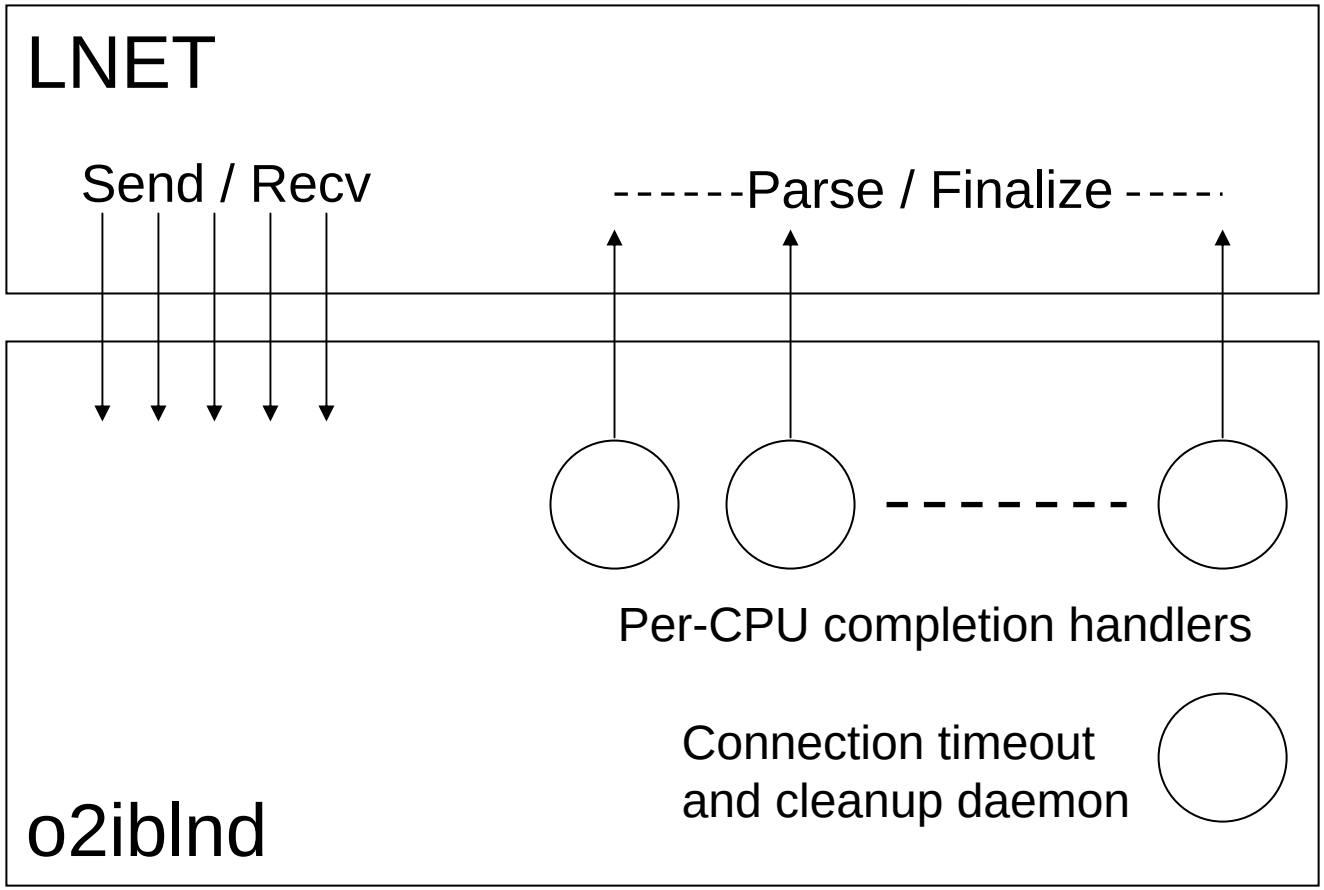
  ib_create_cq
  ib_req_notify_cq
  Ib_destroy_cq

  ib_post_recv
  ib_post_send

  ib_get_dma_mr
  ib_dereg_mr

  ib_create_fmr_pool
  ib_fmr_pool_map_phys
  ib_fmr_pool_unmap
  ib_destroy_fmr_pool

o2iblnd structure



LND state

- **Global**
  - Idle descriptor pool
  - CQ – send completions
  - Connection table
- **Per-connection State**
  - RC QP
  - CQ – receive completions
  - 2 ‘n’ rx buffers – requests + completions
  - Credits
  - Send queues
  - In-progress RDMAs

Connection Setup

- **Additional information passed via CM private data in rdma_{connect,accept,reject}**
- **LND protocol version number**
  - Version interoperation
- **LNET address**
  - Who I am
- **Connection parameters**
  - Credits
  - Max allowed RDMA fragments
- **LND incarnation**
  - Is he the same guy I spoke with 10 minutes ago?

LND protocol

- **Paranoia**
  - Source / Destination address + incarnation
- **Credits**
  - Piggy-back on all messages
  - Back-pressure
- **Message Passing**
  - Noop
  - Immediate
- **RDMA setup / completion**
  - PUT
    - Request
    - ACK / NAK
    - Done
  - GET
    - Request
    - Done

Error Handling

- **RDMA descriptor == Murder Weapon**
- **Error Sources**
  - Underlying stack
  - Timeouts
- **Error Handling**
  - 1. rdma_disconnect()
  - 2. Wait for all completions
  - 3. lnet_finalize()

RDMA

- **Pre-map all memory**
  - Many RDMA fragments
  - Higher Bandwidth!
  - Higher CPU?
- **Map on demand**
  - FMR pool
    - Mapping cache
  - Lower Bandwidth!
  - Lower CPU?

Performance

- **Latency**
  - Can’t busy-poll in the kernel ☹
  - Interrupt handling relatively HUGE ☹ ☹
- **Bandwidth**
  - LNET MTU typically 1MByte
    - Finesses latency issues ☺☺☺
  - ~600MBytes/sec - single pair of nodes
  - > 900MBytes/sec into server with 2 or more clients