The Effect of InfiniBand In-Network Computing on LS-DYNA Simulations

12th European LD-DYNA Conference (2019)
The HPC-AI Advisory Council

- World-wide HPC non-profit organization
- More than 400 member companies / universities / organizations
- Bridges the gap between HPC-AI usage and its potential
- Provides best practices and a support/development center
- Explores future technologies and future developments
- Leading edge solutions and technology demonstrations
HPC Advisory Council Members
HPC-AI Advisory Council Cluster Center (Examples)

- Supermicro / Foxconn 32-node cluster
  - Dual Socket Intel Xeon Gold 6138 CPU @ 2.00GHz

- Dell™ PowerEdge™ R730/R630 36-node cluster
  - Dual Socket Intel® Xeon® 16-core CPUs E5-2697A V4 @ 2.60 GHz

- IBM S822LC POWER8 8-node cluster
  - Dual Socket IBM POWER8 10-core CPUs @ 2.86 GHz
  - GPU: NVIDIA Kepler K80 GPUs
Multiple Applications Best Practices Published

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Data as a Resource

20th Century

21st Century
From CPU-Centric to Data-Centric Data Centers

Everything

CPU

Network
From CPU-Centric to Data-Centric Data Centers

Workload

Communication Framework (MPI)

Network Functions

In-CPU Computing

In-Network Computing
In Network Computing

CPU-Centric (Onload)

Data-Centric (Offload)

Must Wait for the Data
Creates Performance Bottlenecks

Analyze Data as it Moves!
Higher Performance and Scale
SHARP - Scalable Aggregation and Reduction Technology

- **Reliable Scalable General Purpose Primitive**
  - In-network Tree based aggregation mechanism
  - Large number of groups
  - Multiple simultaneous outstanding operations

- **Applicable to Multiple Use-cases**
  - HPC Applications using MPI / SHMEM
  - Distributed Machine Learning applications

- **Scalable High Performance Collective Offload**
  - Barrier, Reduce, All-Reduce, Broadcast and more
Micro Benchmark – MPI Allreduce Latency

- **Oak Ridge National Laboratory – Coral Summit Supercomputer**
Micro Benchmark – MPI Allreduce Throughput

InfiniBand SHARP AllReduce Throughput Advantages
(32 Nodes, 1PPN, Small Messages)
LSTC LS-DYNA

- **LS-DYNA**
  - A general purpose structural and fluid analysis simulation software package capable of simulating complex real world problems
  - Developed by the Livermore Software Technology Corporation (LSTC)

- **LS-DYNA used by**
  - Automobile
  - Aerospace
  - Construction
  - Military
  - Manufacturing
  - Bioengineering
Benchmark Setup

- 16 Dual Socket Intel Xeon Gold 6138 CPU @ 2.00GHz servers
- InfiniBand HDR and HDR100 ConnectX-6 InfiniBand adapter and switch
- InfiniBand Mellanox EDR ConnectX-5 InfiniBand adapter and switch
- Omni-Path Host Fabric Adapter and switch
- 192GB DDR4 2677MHz RDIMMs per node
- OS: CentOS 7.6, kernel 3.10.0-957.1.3.el7.x86_64
- Mellanox OFED: 4.5-1
- Intel IFS 10.9.0.0.2.1.0
- HPC-X 2.4 / IMPI 2018
- LS-DYNA 11 Single Precision
- I/O – local HDD
3cars Profiling - % of MPI Time

- MPI_Recv
- MPI_Bcast
- MPI_Wait
- MPI_Alltoall
- MPI_Barrier
- MPI_Send
- MPI_Isend
- MPI_Irecv
- MPI_Allgather
- MPI_Alltoallv
- MPI_Waitall
- MPI_Comm_dup
3cars Profiling – Communication Balance
3cars Profiling – Message Buffer Size
3cars Profiling – Memory Usage
3 Vehicle Collision (3cars)
3 Vehicle Collision (3cars)

LS-DYNA 3 Vehicle Collision

Jobs/day

16 Nodes

OmniPath    HDR100 InfiniBand    InfiniBand HDR

104%
Summary

- HPC cluster environments impose high demands on connectivity throughput and low latency with low CPU overhead, network flexibility, and high efficiency

- Fulfilling these demands enables the maintenance of a balanced system that can achieve high application performance and high scaling

- With the increase in number of CPU cores and application threads, there is a need to develop a new HPC cluster architecture - a data-focused architecture

- The Co-Design collaboration enables the development of In-Network Computing technology that breaks the performance and scalability barriers

- The LS-DYNA 3 Vehicle Collision (3cars) input was benchmarked for this study to demonstrate the advantages of In-Network Computing technology

- We have witness 18% performance advantage and linear scalability with HDR100 InfiniBand In-Network Computing technology comparing to Omnipath

- We have witness 104% performance advantage and linear scalability with HDR InfiniBand In-Network Computing technology comparing to Omnipath
2019 HPC-AI Advisory Council Activities

- **HPC-AI Advisory Council**
  - Application best practices, case studies
  - Benchmarking center with remote access for users
  - World-wide conferences
  - Visit our community [https://hpcadvisorycouncil.atlassian.net/](https://hpcadvisorycouncil.atlassian.net/)

- **2019 Conferences**
  - USA (Stanford University) – February
  - Switzerland (CSCS) – April
  - Australia - August
  - Spain (BSC) – Sep
  - China (HPC China) – October

- **2019 Competitions**
  - APAC HPC-AI Competition - March
  - China Annual RDMA Competition - May
  - ISC Germany Annual Student Cluster Competition - June

- **For more information**
  - [www.hpcadvisorycouncil.com](http://www.hpcadvisorycouncil.com)
  - info@hpcadvisorycouncil.com
Thank You