Fast and generic concurrent message-passing

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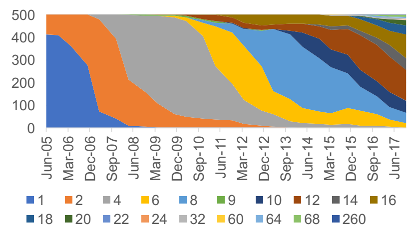
MOTIVATIONS

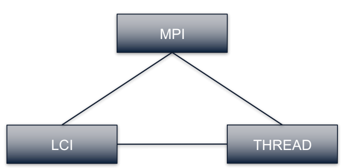
- Cluster and supercomputer architecture grows increasingly more cores, more heterogeneous
- Data movements become more expensive and cache coherency does not scale for implicit communication
- Growing interest in high-performance networking in non-traditional scientific computing applications: machine-learning, data/graph analytics
- Message-Passing Interface (MPI) is being used, but the performance is not ideal



The number of machine with higher number of cores/socket increases each year in the TOP 500 supercomputers list

CONTRIBUTIONS

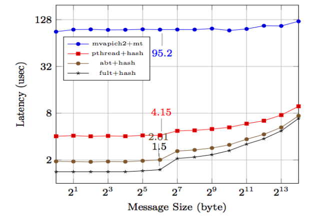
- Study and evaluation of MPI semantics and performance under emerging assumptions and architectures
- Design and Implementation of LCI, a low-level and efficient communication interface targeting multi-threaded, event-driven, heterogeneous frameworks
- Development of new thread synchronization and scheduling techniques for efficient inter-operation between threads, communication runtimes



MPI performance and analaysis [EuroMPI'16 (best-paper), CCGrid'17]

Case study and implementation with MPICH 3.1 performance with threads:
- MPI_THREAD_MUTLIPLE performs poorly in high thread contentions
- Cooperative scheduling techniques improve latency by 3x
- Advanced lock with unbounded-bias improves message rate by 4x
- Implementations are being incorporated into MPICH [mpich/pull/3068]

Design and implementation of message-passing point-to-point:
- MPI relaxation of wildcard matching
- Efficient low-contention tag-matching using hash-table
- Dedicated communication server minimizes data movement
- User-Level Tasking minimizes thread synchronizations



[EuroMPI'16] **Hoang-Vu Dang**, Marc Snir, and William Gropp. **"Towards millions of communicating threads."**
[CCGrid'17] **Hoang-Vu Dang**, Sangmin Seo, Abdelhalim Amer, and Pavan Balaji.**"Advanced Thread Synchronization for Multithreaded MPI Implementations.**

LCI: generic and low-overhead communication interface [IPDPS'18, PLDI'18]

LCI design principles are to decouple:
- producer-consumer matching: tag, un-tag, one-sided, two-sided
- completion events and progress: completion queue, completion signal
- fatal-error and recoverable errors: retry when recoverable
- high-level, low-level features: maintains simple network primitives

	bfs	cc	pagerank	sssp
LCI	**1.17**	**2.41**	**89.72**	**2.46**
IntelMPI-Probe	1.41	2.95	174.67	2.94
MVAPICH2-Probe	1.40	2.93	177.72	2.82
OpenMPI-Probe	1.33	2.99	171.57	2.82
IntelMPI-RMA (+1.4)	**1.06**	2.36	**87.84**	**1.93**
MVAPICH2-RMA (+1.8)	1.14	**2.29**	93.53	2.13
OpenMPI-RMA (+1.2)	1.21	2.34	93.74	2.25

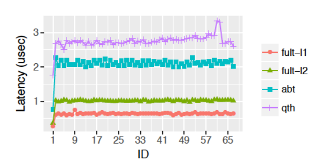
LCI extends the state-of-the-art performance for graph frameworks
- D-Galois: issues with flow-control and data management
- Gluon: issues with heterogeneity in computing architecture for graphs

[IPDPS'18] **Hoang-Vu Dang**, Roshan Dathathri, Gurbinder Gill, Alex Brooks, Nikoli Dryden, Andrew Lenharth, Loc Hoang, Keshav Pingali, and Marc Snir. **"A lightweight communication runtime for distributed graph analytics."**
[PLDI'18] Roshan Dathathri, Gurbinder Gill, Loc Hoang, **Hoang-Vu Dang**, Alex Brooks, Nikoli Dryden, Marc Snir, and Keshav Pingali, **"Gluon: A communication optimizing framework for distributed heterogeneous graph analytics"**

THREAD: Fast synchronizations for communication [ICPP'18, ESPM2'15]

Signal/Wait for schedule/de-scheduleing tasks on distributed events:
- Communication server receives messages and signal a waiting thread
- Optimizing signal/wait improves performance of communication with high number of threads

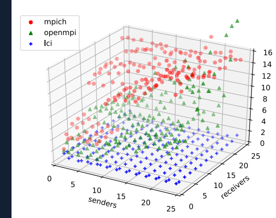
FULT is a Fast User-Level Threading scheduling technique:
- Each work queues of a worker is a bit-vector
- Hierarchical bit-vectors for millions of tasks per node
- Load-balancing using work-stealing, highly scalable synchronizations
- Performance improvement upto 6x vs Argobots and Qthreads.



[ICPP'18] **Hoang-Vu Dang**, and Marc Snir, **"FULT: A Fast User-Level Thread Scheduling using bitvectors"**
[ESPM2'15] Alex Brooks, **Hoang-Vu Dang**, Nikoli Dryden, Marc Snir, **"PPL: An abstract runtime system for hybrid parallel programming"**

CONCLUSIONS

- MPI performance is lagging behind due to the changes in architecture and usages
- Performance of message-passing can be improve with better concurrent data structures and some relaxations in semantics.
- LCI represents a clean ground-up design, highly integrated with threads
- FUTL is a technique for scalable communication synchronization.
- Future work: a standard API for LCI, release of FULT software package, integration to OpenMP



LCI+FULT outperforms MPICH and OpenMPI on OpenMP using multi-threaded point-to-point varying number of sender or receiver threads.

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Galois

CONTACTS AND LINKS

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LCI: https://github.com/danghvu/LCI

UIUC-HPC: https://github.com/uiuc-hpc

D-Galois: http://iss.ices.utexas.edu/?p=projects/galois

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