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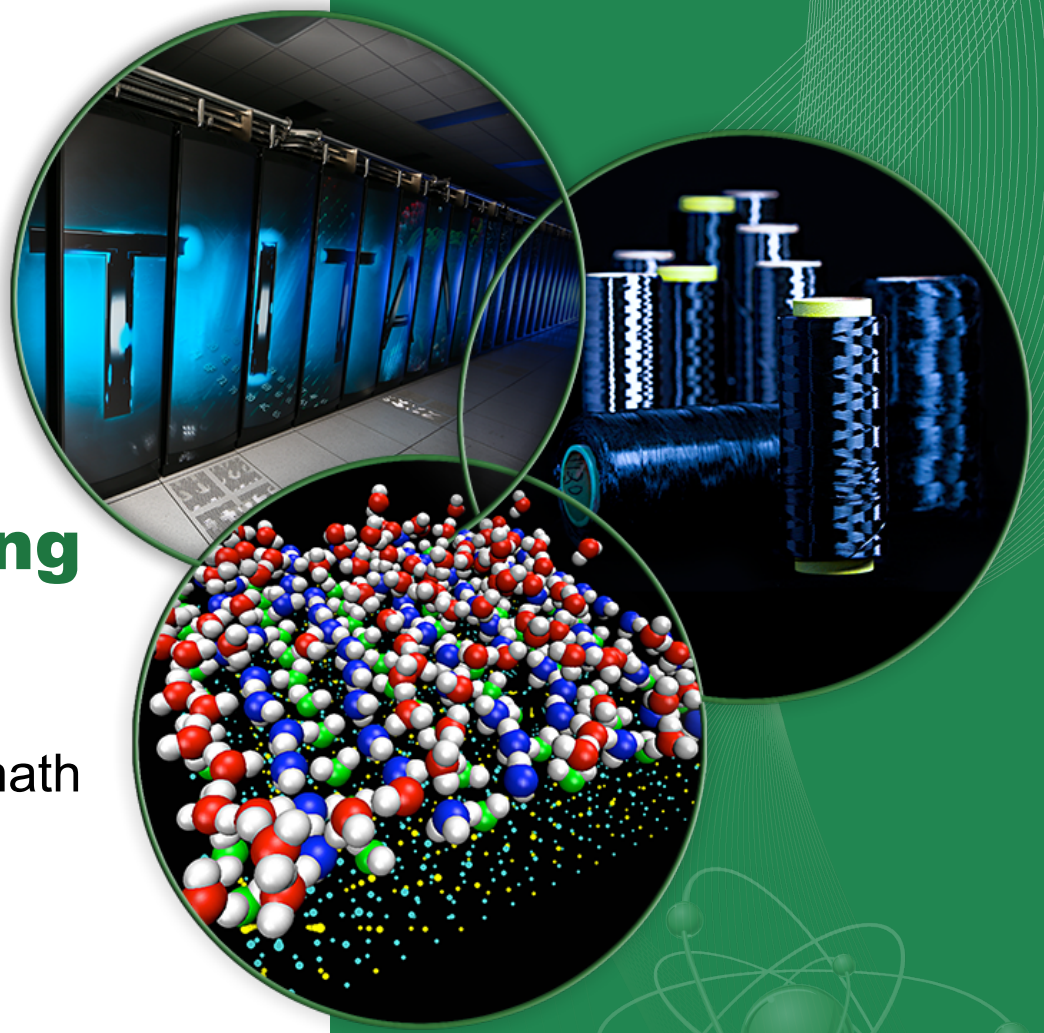

OpenSHMEM-UCX : Evaluation of UCX for implementing OpenSHMEM Programming Model

Languages R&D

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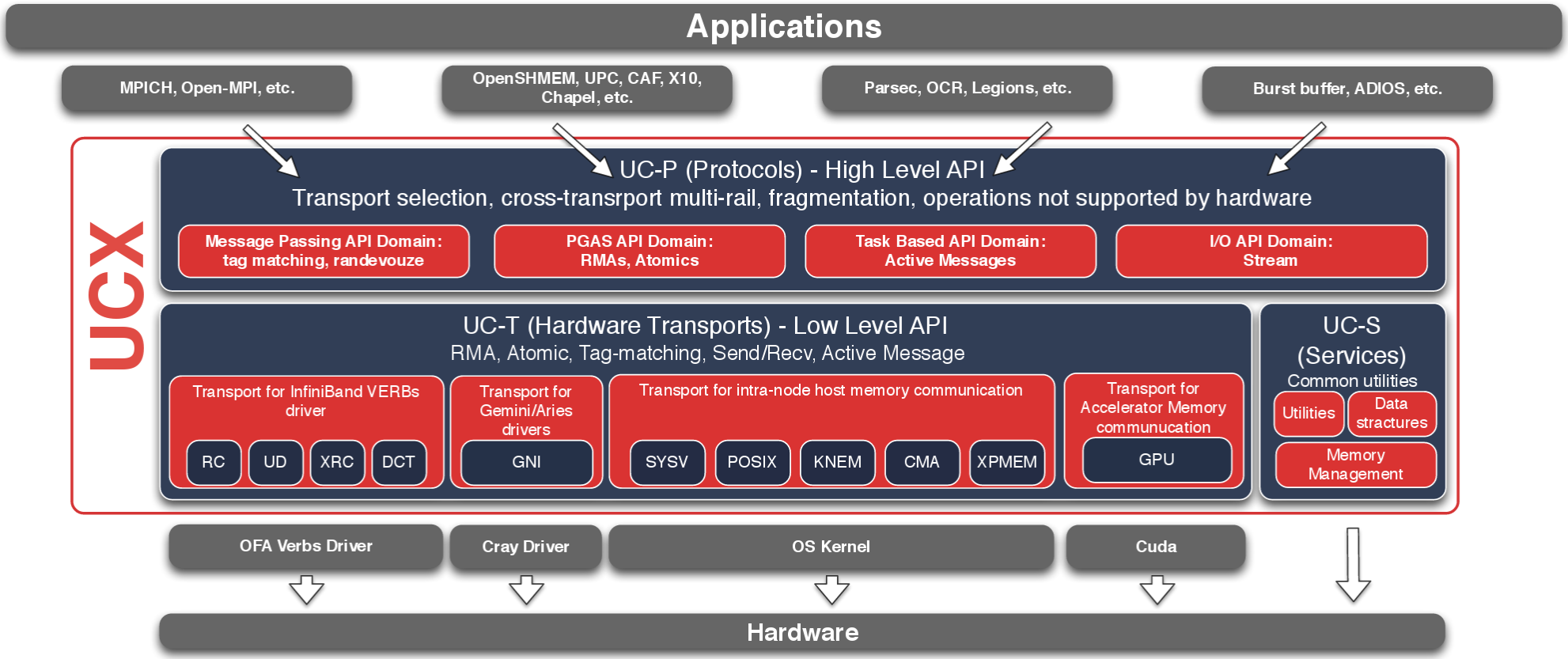
UCX

- Unified Communication layer X
- Framework for communication
- Portable performance
- Scalability

Why UCX is good for PGAS

- UCX developed in close relation with OpenSHMEM team
- Performance Oriented
  - UCX a light weight layer over hardware
  - OpenSHMEM should be a lightweight layer over UCX
- Portable
  - Targeting upper layer UCX protocol allows easy portability with low level transports

UCX Design


Applications
MPICH, Open-MPI, etc.
OpenSHMEM, UPC, CAF, X10, Chapel, etc.
Parsec, OCR, Legions, etc.
Burst buffer, ADIOS, etc.
UCX
UC-P (Protocols) - High Level API
Transport selection, cross-transrport multi-rail, fragmentation, operations not supported by hardware
Message Passing API Domain: tag matching, randevouze
PGAS API Domain: RMAs, Atomics
Task Based API Domain: Active Messages
I/O API Domain: Stream
UC-T (Hardware Transports) - Low Level API
RMA, Atomic, Tag-matching, Send/Recv, Active Message
Transport for InfiniBand VERBs driver
RC
UD
XRC
DCT
Transport for Gemini/Aries drivers
GNI
Transport for intra-node host memory communication
SYSV
POSIX
KNEM
CMA
XPMEM
Transport for Accelerator Memory communucation
GPU
UC-S (Services)
Common utilities
Utilities
Data stractures
Memory Management
OFA Verbs Driver
Cray Driver
OS Kernel
Cuda
Hardware

UCX layers

- UCT
  - Supports specific hardware
  - Currently supported: Cray UGNI, Mellanox IB, shared memory
  - Abstractions
    - Memory domain (md)
      - Memory registration
    - Interface (iface)
      - A particular interface to a network device
    - End Point (ep)
      - A particular point to point communication object
    - Worker
      - ensures that underlying network hardware makes progress

UCX layers

- UCP
  - Provides protocol abstractions.
  - Abstracts away common high level tasks
    - Selects best mechanism for transfers
    - Wiring up end points
    - Selecting transports
    - Tagged messages
  - Implements missing features
    - 32 bit atomics on Gemini
  - Workers
    - Provides application contexts, one application can have multiple progress threads

UCX layers

- UCS
  - Common platform services
    - Local atomics
    - Thread safety
  - Data structures
  - Debug and logging output
- UCM
  - Memory management
  - Manages registration caches

UCX on Cray hardware

- UCT on Cray has 3 different transports
  - FMA and BTE APIs in RDMA transport
  - SMSG short messages in SMSG transport
  - Datagrams in UDT transport
- Each exposes different capabilities in UCT
  - RDMA exposes RMA bcopy/zcopy
  - SMSG exposes active messages
  - UDT exposes active messages on interfaces

OpenSHMEM on UCX on Cray

- OpenSHMEM only requires the RDMA transport.
  - UCX will, on its own, only initialize RDMA and skip SMSG
- Nothing special required, other than passing in correct feature flags

OpenSHMEM on UCX

- OpenSHMEM becomes thin on UCX
- Atomics and put/gets done directly through UCP.
- Collective operations and handled by OpenSHMEM
- OpenSHMEM handles memory, but UCX has hardware specific knowledge
  - OpenSHMEM registers memory, receives keys
  - UCX worries about how to register memory with driver

Benchmark results

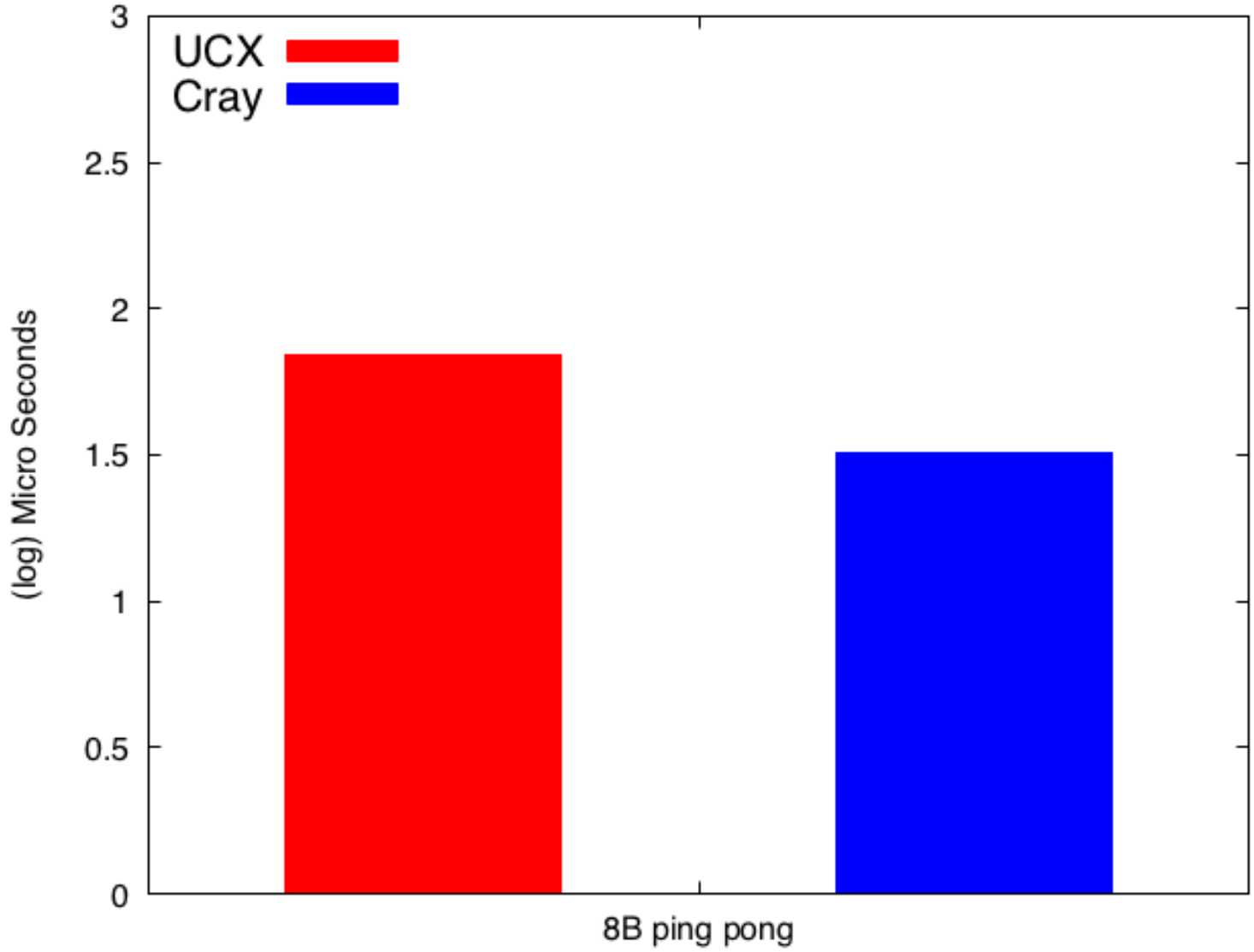
Test System

- Titan
  - 18,688 nodes
  - 16 core AMD cpu per node
  - 32 GB of memory per node
  - Nvidia K20X accelerator

Modified OSU benchmark

- Ping pong test
  - Bouncing puts between two nodes

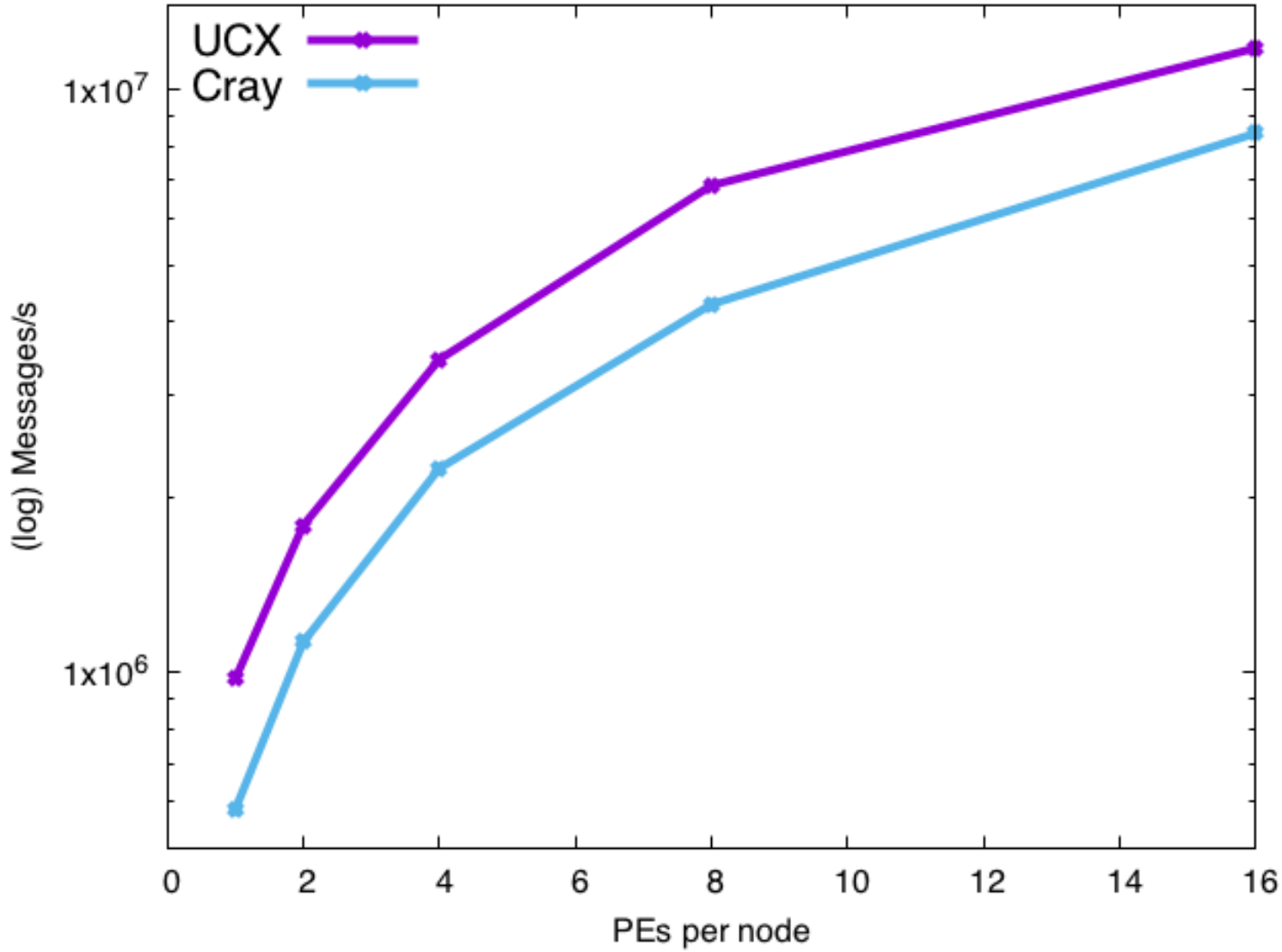
Ping pong test (lower is better)



OSU message rate

- Message rate benchmark from OSU benchmark suite
- Graphed results for 8 byte puts between two nodes, going from 1 PE per node to 16

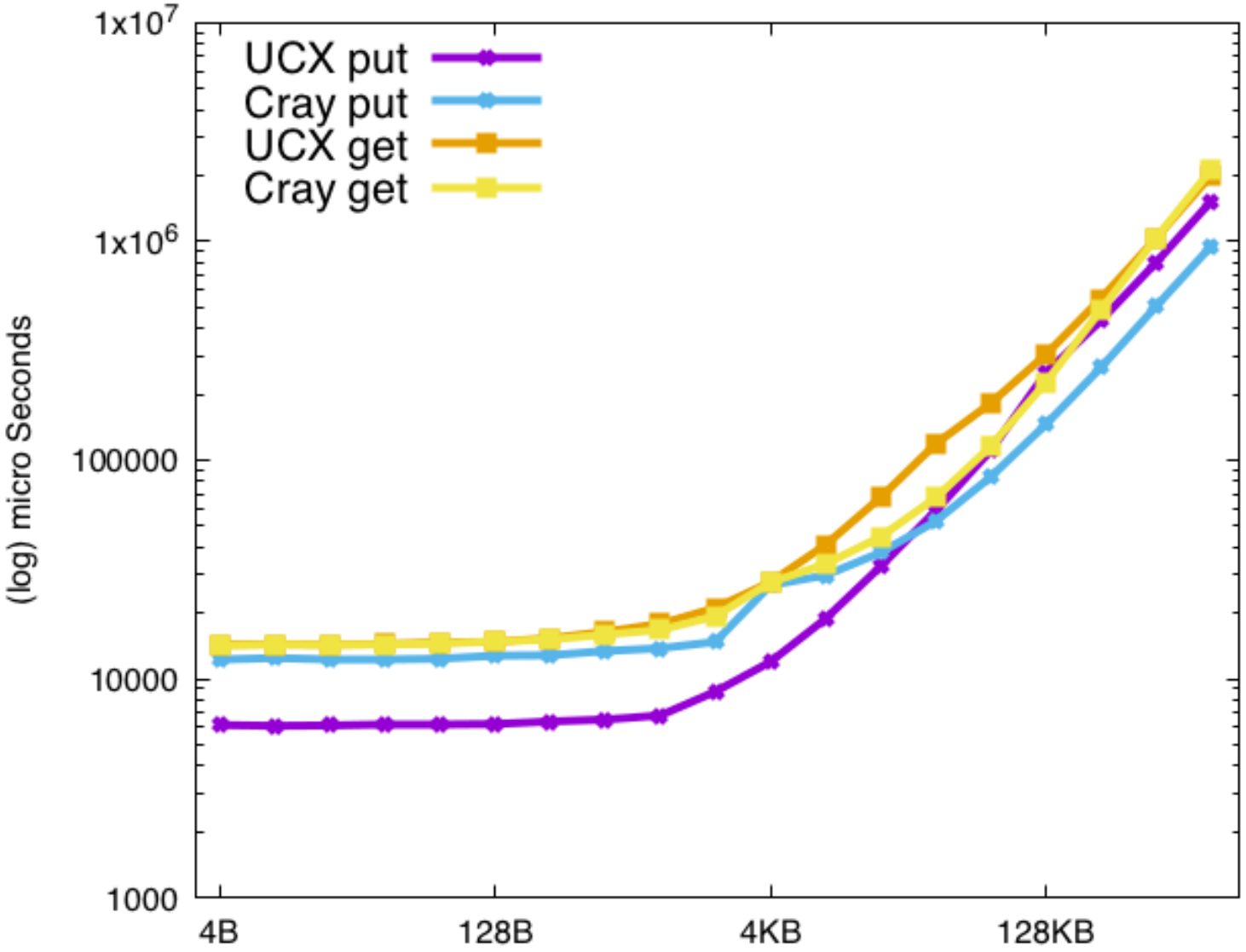
Message Rate



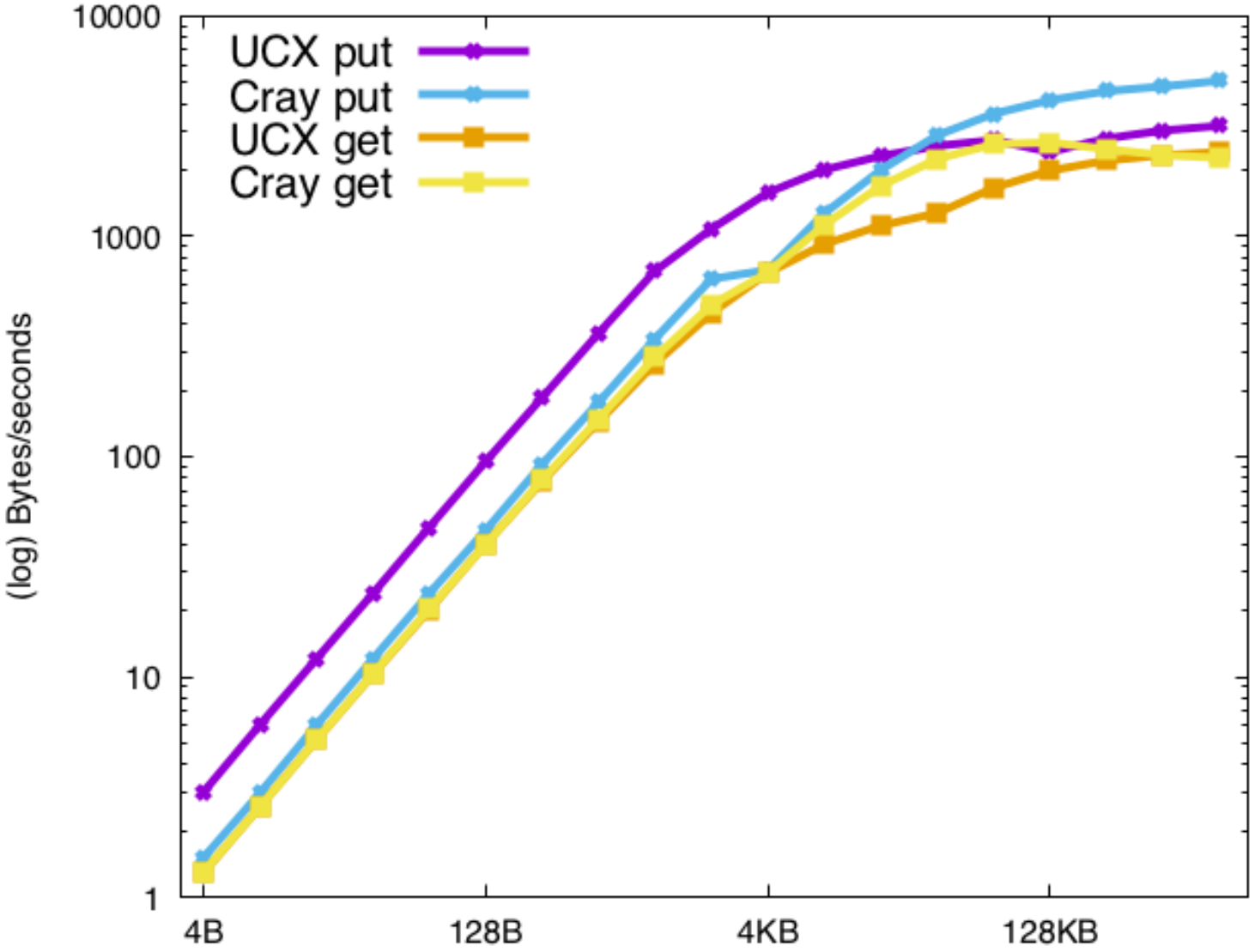
SHOMS tests

- SHOMS is a OpenSHMEM microbenchmark suite
  - Tests cover entire OpenSHMEM API
- Test results
  - One origin PE sending to 4095 other PEs
  - Latency from 4B to 1MB
  - Bandwidth from 4B to 1MB

SHOMS latency test



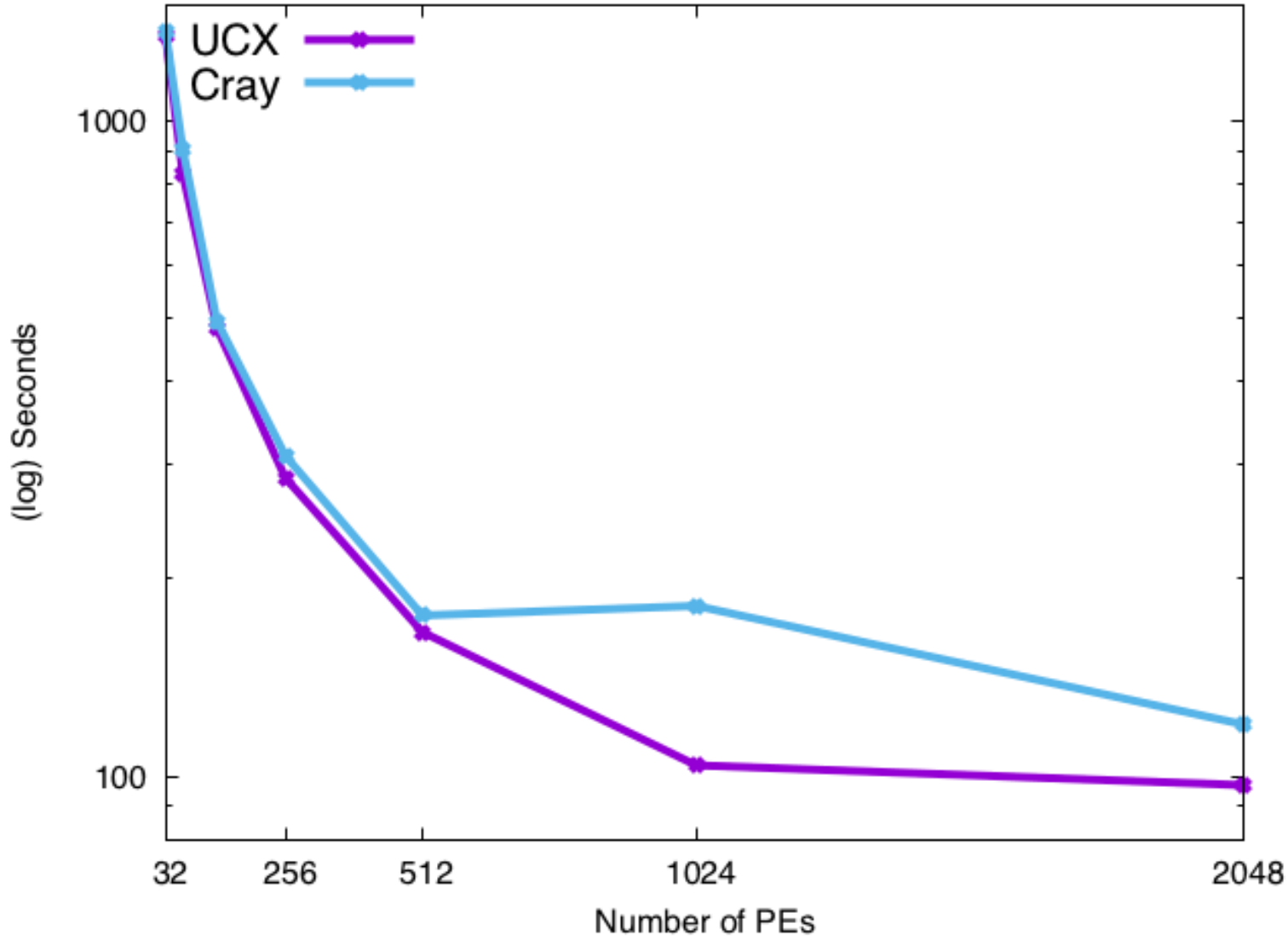
SHOMS bandwidth



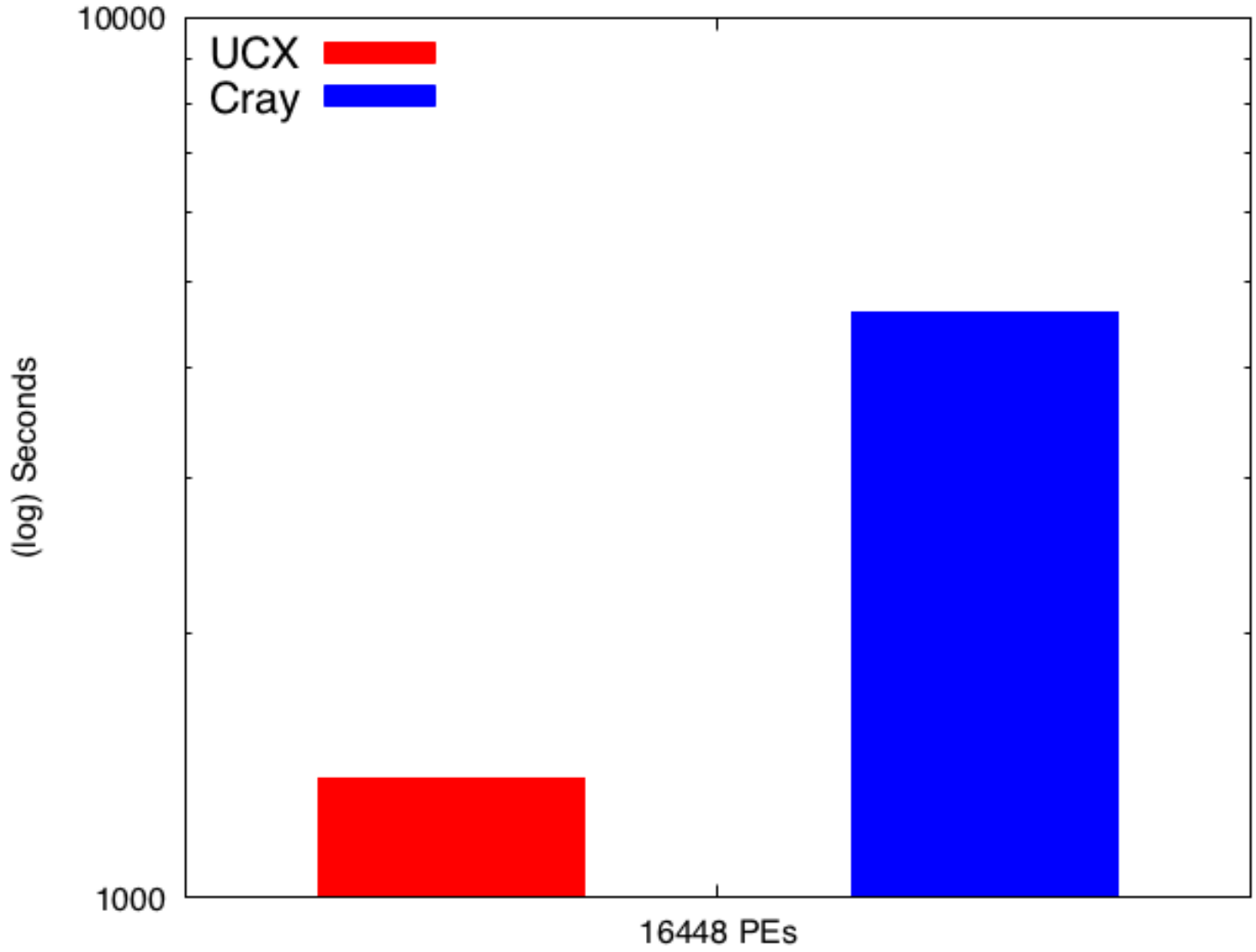
SSCA1 Smith-Waterman

- Genetic local alignment benchmark
- Large parallel inner loop with many short puts and gets
  - 7 gets and 5 puts
- Extremely sensitive to message rates

SSCA1 up to 2048 PEs



SSCA1 16k PEs



Conclusions

- Implementing OpenSHMEM over UCX is light weight
- UCX provides useful abstractions for high performance and high through put
  - Workers, interfaces, endpoints arbiters
- Evaluation of microbenchmarks and kernels prove usefulness
  - Short put and get message rates
  - Still work to be done (improved management of memory registrations)

Acknowledgements

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