OpenSHMEM Extensions Towards Hybrid Programming and Heterogeneous Computing

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OpenSHMEM Extensions

Objectives for this talk

- Overview of 6 features being proposed for OpenSHMEM that are based on features currently in Cray SHMEM
- Our goal is to advance OpenSHMEM with new, desirable, and proven features
- Today's audience:
  - For some, these are new concepts
  - For some, you are asking for these
  - For some, you are already involved in discussing
- See our paper for more details; see Redmine for full
- A starting point for discussion with OpenSHMEM community

OpenSHMEM Extensions

What makes for a desirable, new OpenSHMEM feature?

- **Improves ease of OpenSHMEM programming**
- **Improves performance of OpenSHMEM programs**
- **User friendly API**
- **Aids portability by hiding system differences in specific implementations**
- **Consistent with existing OpenSHMEM API**

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Why do we need more than current API?
Primarily due to trends in system architectures for exascale:

- Increased complexity
- Increasing number of cores in multi-core processors
- memory hierarchies
  - distributed and shared and high bandwidth
- Processor accelerators
- Increased network capabilities to offload communication work from compute processors
- Other new concepts that help programmability and performance

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The 6 Proposed Features (Redmine Ticket #)

- Alltoall Collectives
- Flexible PE Subsets, a.k.a. Teams
- Thread-Safety
- Local Shared Memory Pointers
- Put With Signal
- Non-Blocking Put and Get

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Alltoall Collectives (Redmine #182, #183)

- All-to-all pattern of communication is common in programs
- Each PE exchanging data with every other PE in the defined set
- Naive implementation usually far from optimal
- Sophisticated implementation complex and can be system-specific - best to hide it in the library

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Alltoall Collectives API – 3 routines

- `shmem_alltoall - fixed size data`
- `shmem_alltoallv - variable size data and variable source/dest offsets`
- `shmem_team_alltoall - using teams syntax (using proposed Teams, see below)`

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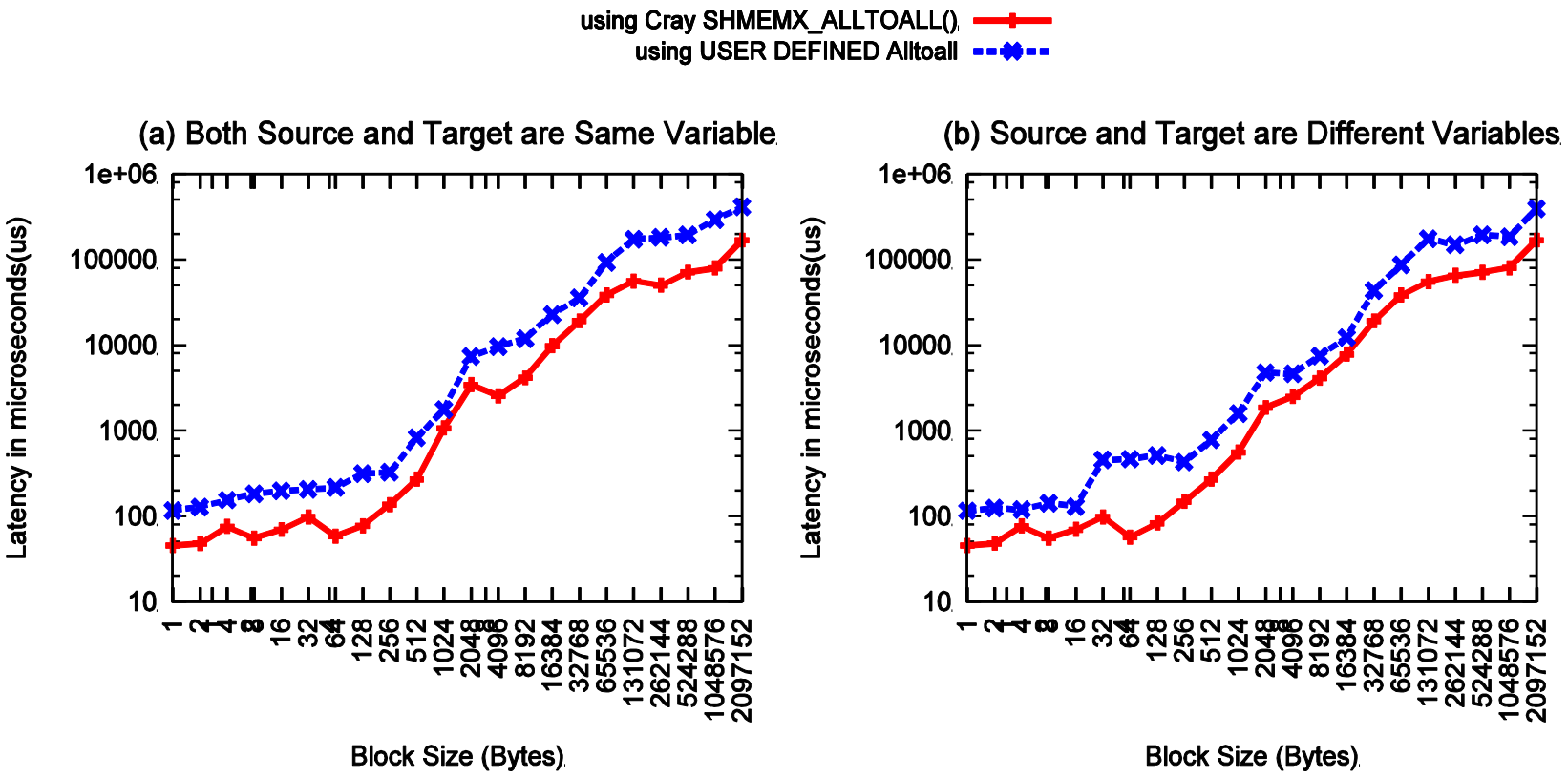
Alltoall Collectives Performance



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Flexible PE Subsets, a.k.a. Teams (Redmine #185)

- An alternative Teams proposal (Redmine #179)
- Current active set specification not flexible enough
- Proposed feature allows a set of PEs to be divided in arbitrary ways
- Similar to MPI and UPC teams : color and key
- Lots of issues to be hashed out

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Flexible PE Subsets API – 7 routines

- shmem_team_split - split existing team as needed using color and key
- shmem_team_create_strided - w/ stride argument, NOT power-of-2
- shmem_team_translate_pe - rank in one team to corresponding rank in another team
- shmem_team_npes - how many in this team
- shmem_team_mype - my rank in this team
- shmem_team_barrier - barrier for just this team
- shmem_team_free - release resources

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Thread-Safety (Redmine #186)

- Hybrid programming such as SHMEM and OpenMP
- Execution by multiple threads per PE can be more efficient than by PEs alone
- Multiple threads per PE can directly access PE's symmetric memory
- OpenSHMEM needs to be thread safe
- Proposed support is basic - Puts, Gets, AMOs
- Can expand API in future as need arises
- Can be used with "Communications Contexts" (Redmine #177)

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Thread-Safety API – 6 routines

- `shmem_init_thread` - in place of `shmem_init`
- `shmem_query_thread` - query current level
- `shmem_thread_register` - required before using a thread
- `shmem_thread_unregister` - when done using a thread
- `shmem_thread_quiet` - completion of outstanding communication
- `shmem_thread_fence` - ordering of communication

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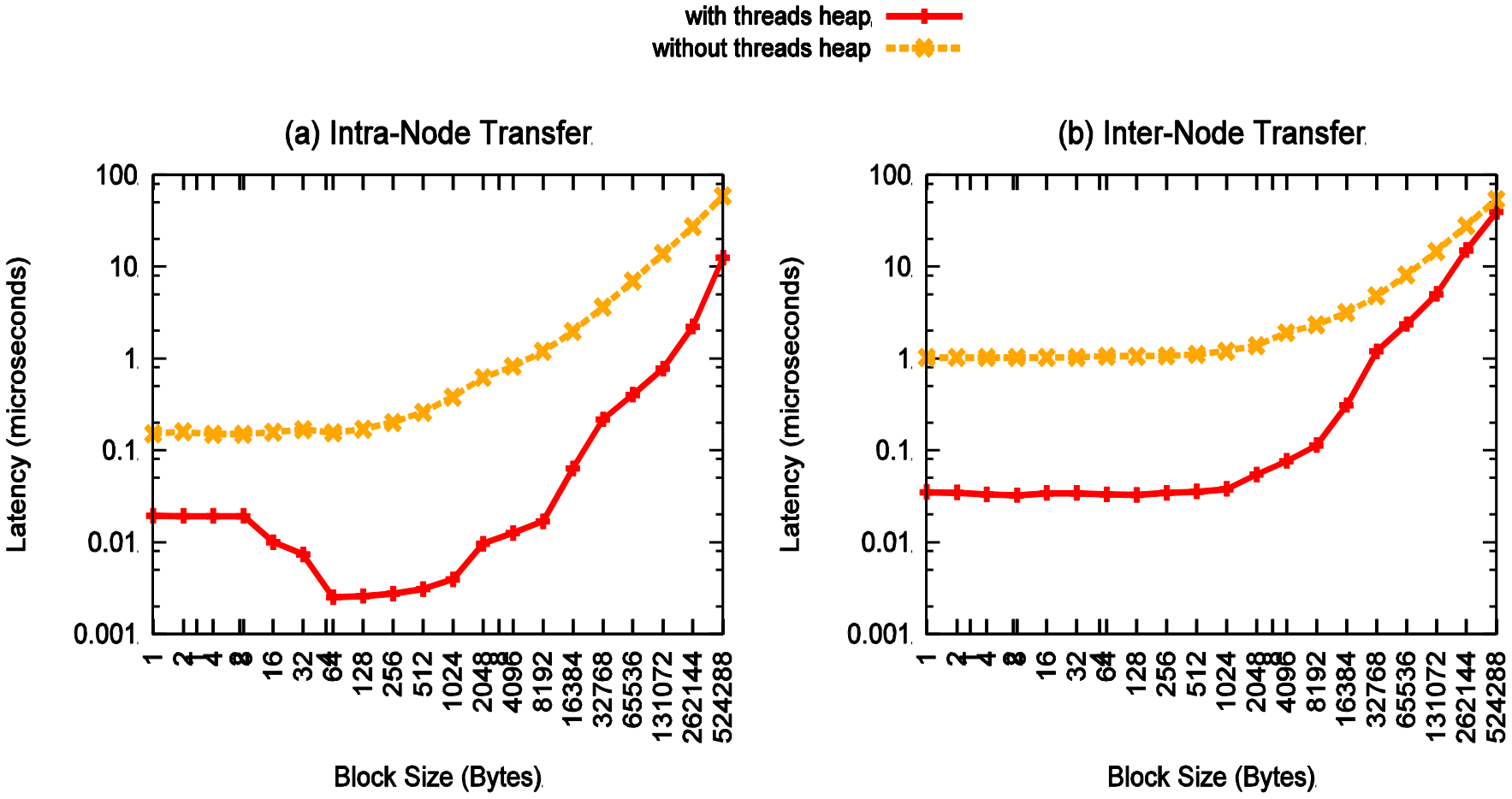
Thread-Safety Performance



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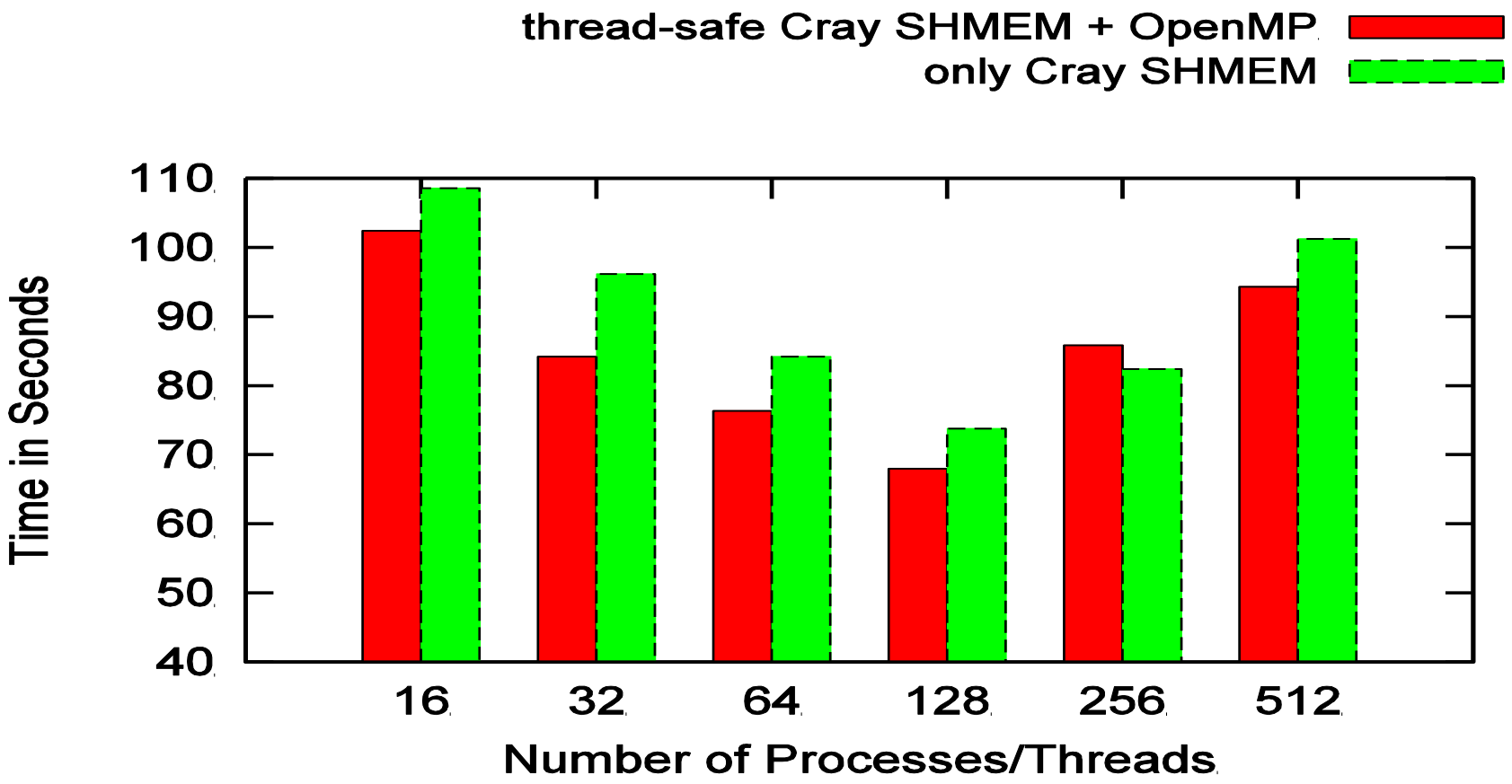
Thread-Safety Performance



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Local Shared-Memory Pointers (Redmine #70)

- shmem_local_ptr is different from shmem_ptr which supports off-node direct references
- shmem_local_ptr is for on-node references
- Local in sense of on same node; define node:
  - group of processors, memory, and network components that acts as a network end point
  - the memory on a node is addressable by all processors on the node without having to go through the network
  - direct addressability can have lower latency and higher bandwidth
- Use when direct on-node references can be more efficient than through API calls

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Local Shared-Memory Pointers API – 3 routines

- `shmem_local_ptr - returns address or NULL`
- `shmem_local_npes - how many PEs are local`
- `shmem_local_pes - which PEs are local`

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Non-Blocking Put and Get (Redmine #113)

- Desirable to overlap communication between PEs and computation by PEs
- Current blocking Put and Get don't allow this
- Overlap by issuing non-blocking call, than later wait for completion

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Non-Blocking Put and Get API

- `shmem_<type>_put_nb`
- `shmem_put<size>_nb`
- `shmem_<type>_get_nb`
- `shmem_get<size>_nb`

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Put With Signal (Redmine #77)

- Combines sending data with sending a signal that data has arrived
- Easier to program
- Potential for better performance
- Blocking and non-blocking implicit versions

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Put With Signal API – many routines

- `shmem_<type>_put_signal`
- `shmem_put<size>_signal`
- `shmem_<type>_put_signal_nb`
- `shmem_put<size>_signal_nb`

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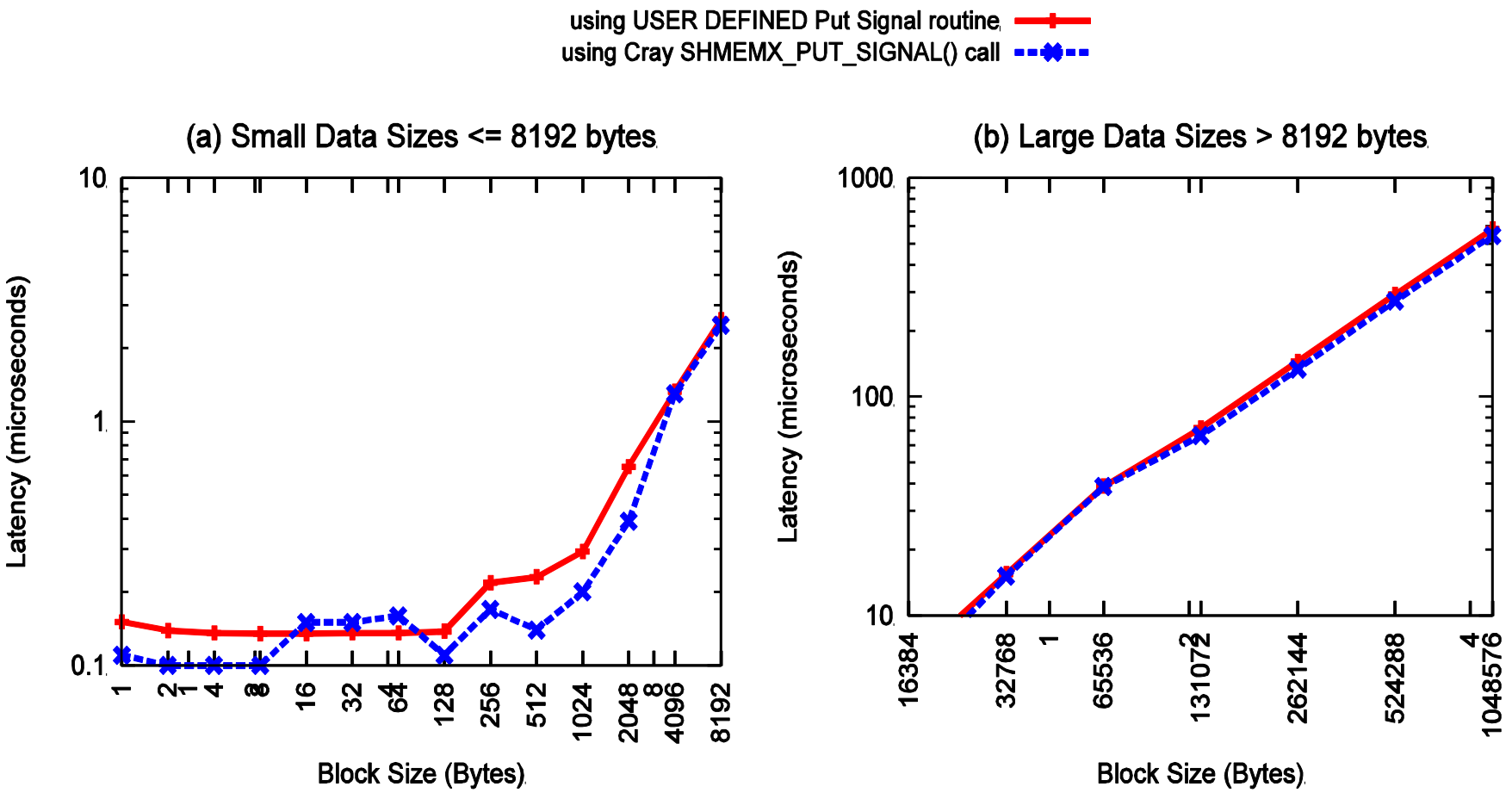
Put With Signal Performance



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Conclusion

- These 6 features have been implemented in Cray SHMEM and are already being used
- We believe these are valuable for many OpenSHMEM programs
- We request all 6 features be given careful consideration for OpenSHMEM API
- We will work within the OpenSHMEM community for consensus

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Acknowledgements

- Monika ten Bruggencate, Kim McMahon, Steve Oyanagi, Nick Radcliffe.

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Question?

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