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EARLY EXPERIENCE IN SUPPORTING ONE-SIDED COMMUNICATIONS ON SLINGSHOT 11

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FoRMA'22

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BACKGROUND – HPE SLINGSHOT

- HPE Slingshot interconnect
  - Discrete PCIe NIC and switch
  - Brings together the best of Ethernet and HPC Interconnects
  - HPE Rosetta – HPE proprietary switch
  - HPE Slingshot NIC (**Slingshot 11**)
    - HPE proprietary NIC
    - Used on ORNL's Frontier exascale system

MOTIVATION

- Introduce and report on various Slingshot 11 features – impacting one-sided communications
- Provide implementation options for MPI RMA

SLINGSHOT 11 NIC FEATURES

- Overview of Slingshot 11 features – impacting the performance of one-sided communication operations

- RMA transfer protocol
  - Determines how data is consumed by Slingshot 11 NIC
  - Inject vs. DMA

- Event completion semantics
  - Early completion notification vs. remote target memory completion notification

- Bundling communication events
  - Transfer single event vs. multiple events together

- Triggered communication operations
  - Deferred execution events

SLINGSHOT 11 NIC FEATURE – RMA PROTOCOLS

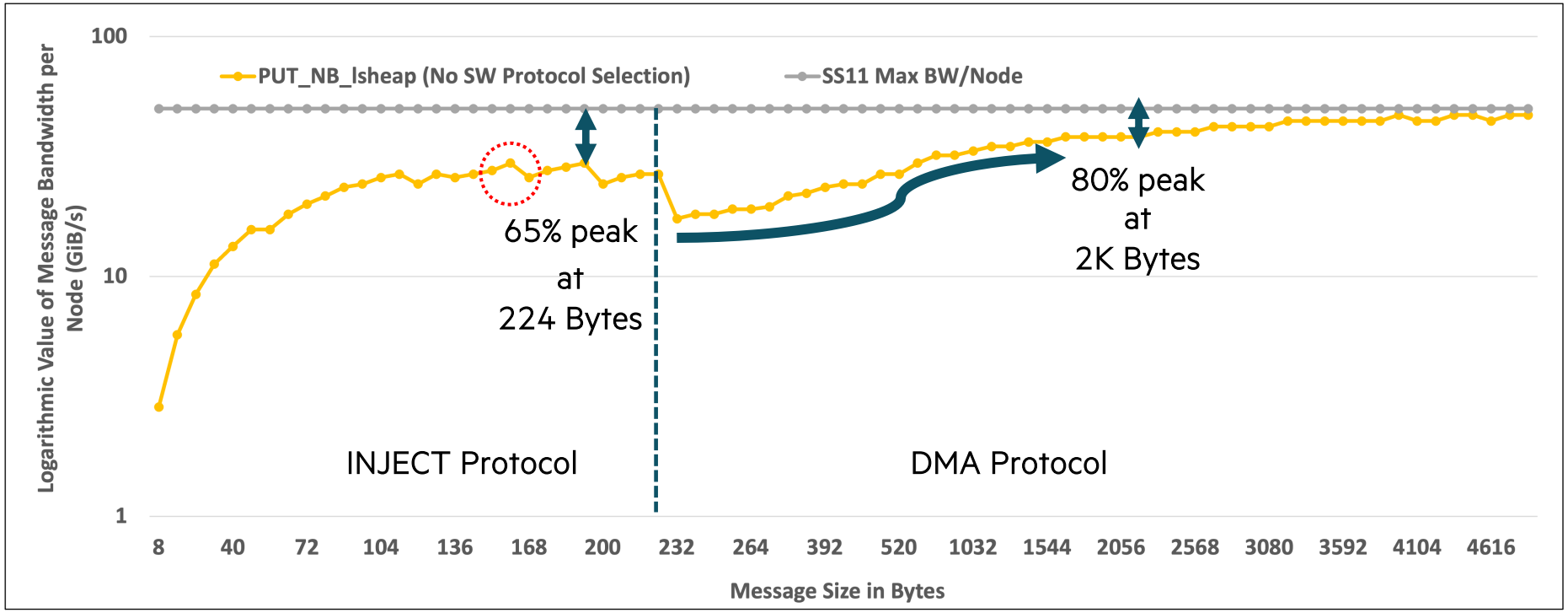
- INJECT
  - Low-latency immediate data commands
  - Message packed with packet header
  - Fixed size limitation

- DMA
  - Message sent separate from the header
  - Message sent as a single or multiple chunks
  - Typically used for large message buffer transfers

RMA PROTOCOL ANALYSIS – DATA SIZE

- Performance impacting factors
  - Data-size – determines RMA protocol selection
  - Source buffer type – determines the need for memory registration

16 Nodes, 128 PPN
Dual-NIC AMD Milan
HPE Random Access MB
NBI PUT BW Analysis



RMA PROTOCOL ANALYSIS – SW PROTOCOL SELECTION

- Performance impacting factors
  - Data-size – determines RMA protocol selection
  - Source buffer type – determines the need for memory registration

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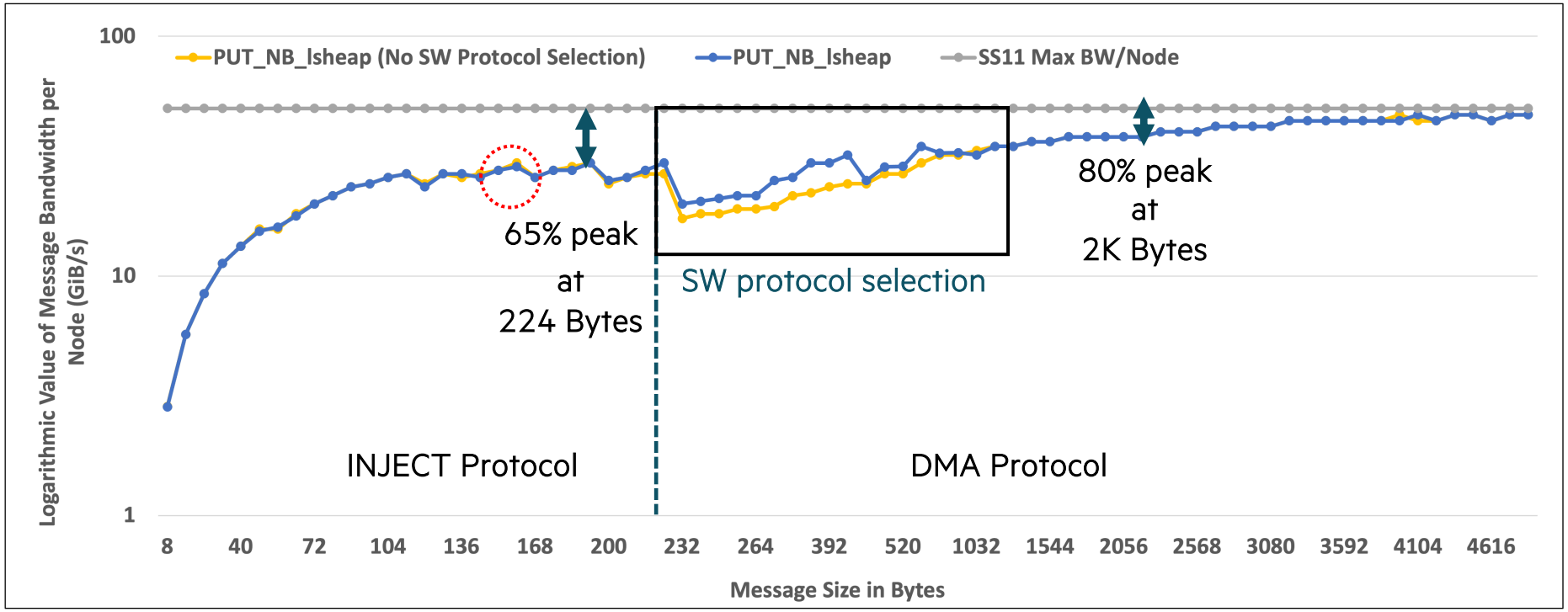

RMA PROTOCOL ANALYSIS – SOURCE BUFFER TYPE

- Impact of source buffer type
  - Target buffer – always a registered memory space
  - Source buffer – (1) symmetric heap, or (2) local heap/stack

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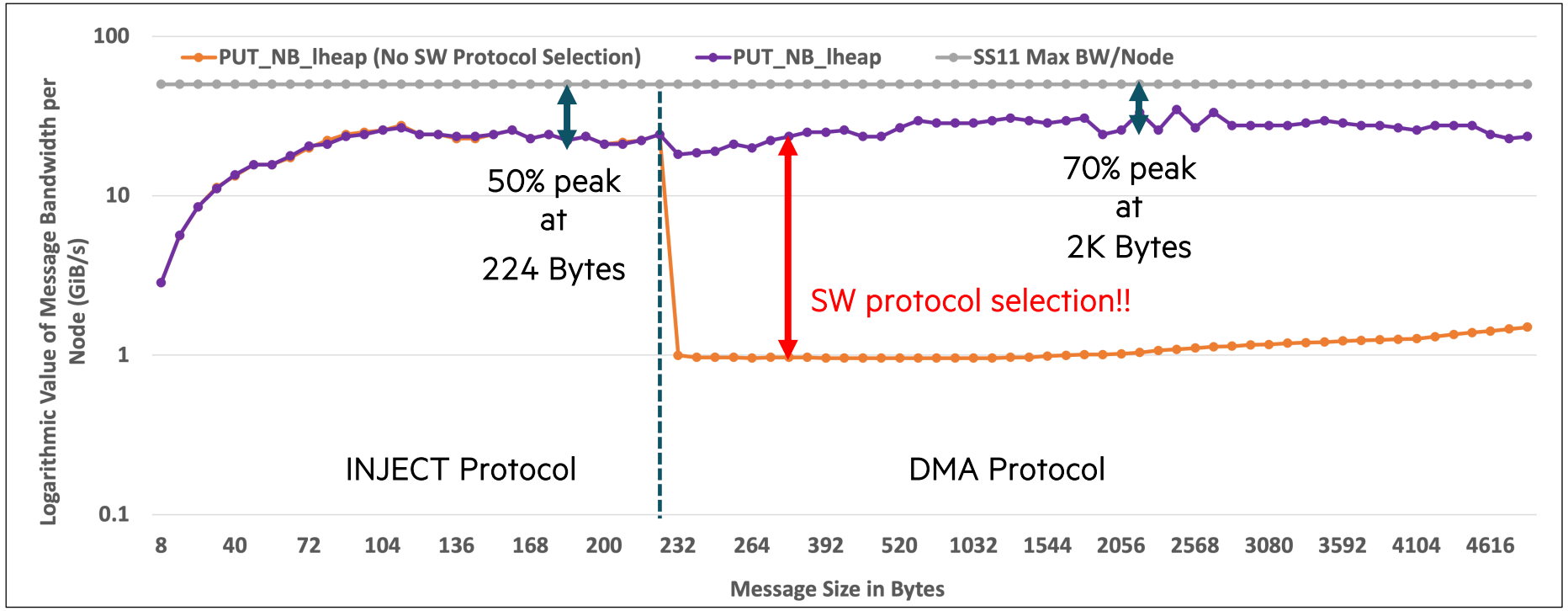


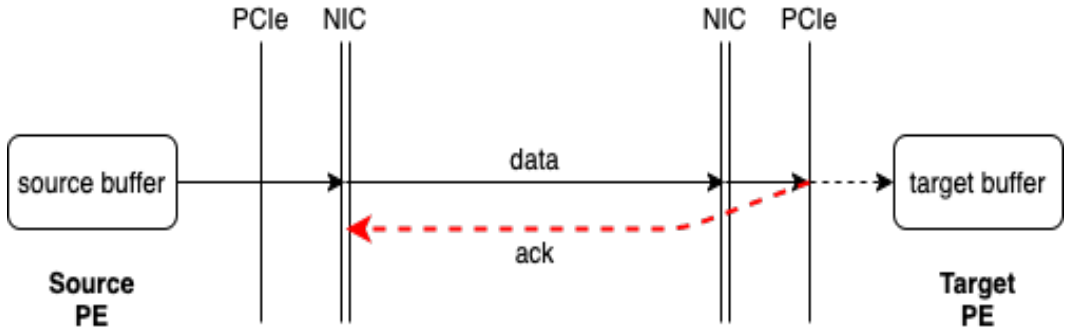
RMA PROTOCOL ANALYSIS

- Overall Inference
  - Use registered memory region as source buffers
  - Using local heap/stack-based source buffers has a performance impact
  - For small-message transfers – data size is critical to achieve peak performance
    – Understanding packet size and protocol selection is critical
  - Transitioning between protocol has performance impact
    – Solution - Use of SW protocol selection module
    – Need application specific inputs for better tuning
    – Highly visible with source buffers on local heap/stack

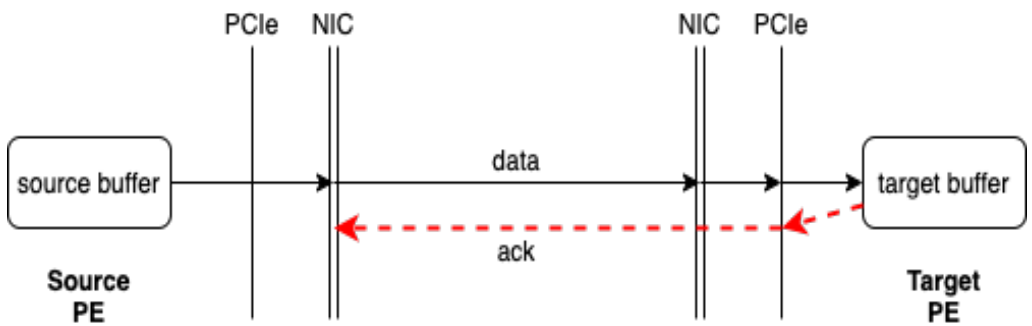
SLINGSHOT 11 NIC FEATURE – EVENT COMPLETION SEMANTICS

- Determines when an MPI RMA operation is completed
  - When can reuse source buffer
  - When the data is guaranteed to be visible on the target memory

- *Types of completions supported by Slingshot 11



Local Completion



Remote target completion

*Different from the completion protocols supported by the libfabric middleware. This slide represents the true completions supported by the Slingshot 11 NIC.

MPI PASSIVE RMA SUPPORTED COMPLETIONS

- MPI RMA (passive) supported completions

	Local completion	Remote target completion
MPI_Put	Return from **MPI_Win_flush_local** or **MPI_Win_flush_local_all**	Return from **MPI_Win_flush** or **MPI_Win_flush_all**

- Is it bad to use remote target completions?
  - No
  - Local completions are used to achieve better communication/computation overlap on pipelined algorithms
  - Scenarios where target visibility is required – remote target completions are still useful

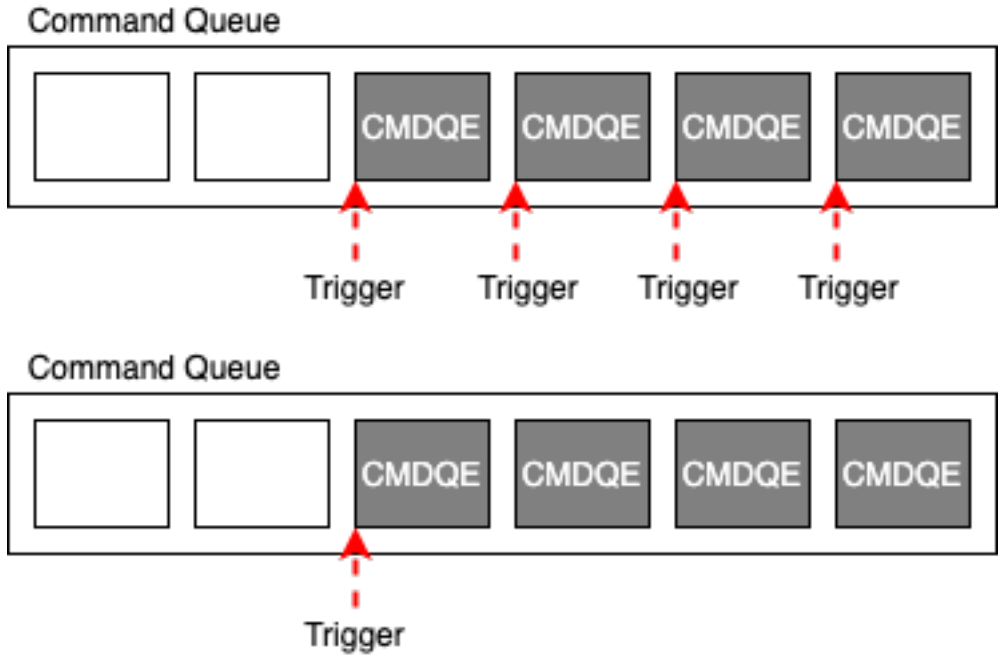
- There is a mismatch in the requirements
  - All completion semantics need to be specified during event launch
  - Not during event completion verification like flush/synch
  - Conservatively - implementations must implement everything as ”locally completed” events
  - **Is there a better option available to specify completions during event launch?**

SLINGSHOT 11 NIC FEATURE – BUNDLING EVENTS

- How to post event in Slingshot 11 ?
  - Prepare and enqueue message packet into Command Queue as CMDQE
  - Trigger the enqueued Command Queue Entries (CMDQE)
  - NIC executes CMDQE as FIFO

- How to trigger CMDQE ?
  - Trigger every event
  - Trigger group of events

- Bundling
  - Group CMDQE and trigger as single operation



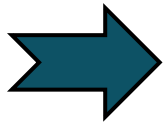
EXAMPLE FOR BUNDLING SUPPORT WITH OPENSHMEM

- No option to bundle OpenSHMEM operations
- OpenSHMEM Sessions
  - Epoch in an application
  - Users provide hints for the epoch
  - Hints allow better NIC resource management
  - Similar to ***#pragma*** directives in C language

```
void shmemx_ctx_session_start (IN shmem_ctx_t ctx, IN int options);
void shmemx_ctx_session_stop (IN shmem_ctx_t ctx);
```

- Need to adapt as epoch-based MPI RMA hints

```
for (int i = 0; i < n; i++) {
        shmem_put_nbi (SHMEM_CTX_DEFAULT,
                       src + off[i], dst + off[i],
                       nelems, i);
}
shmem_quiet();
```



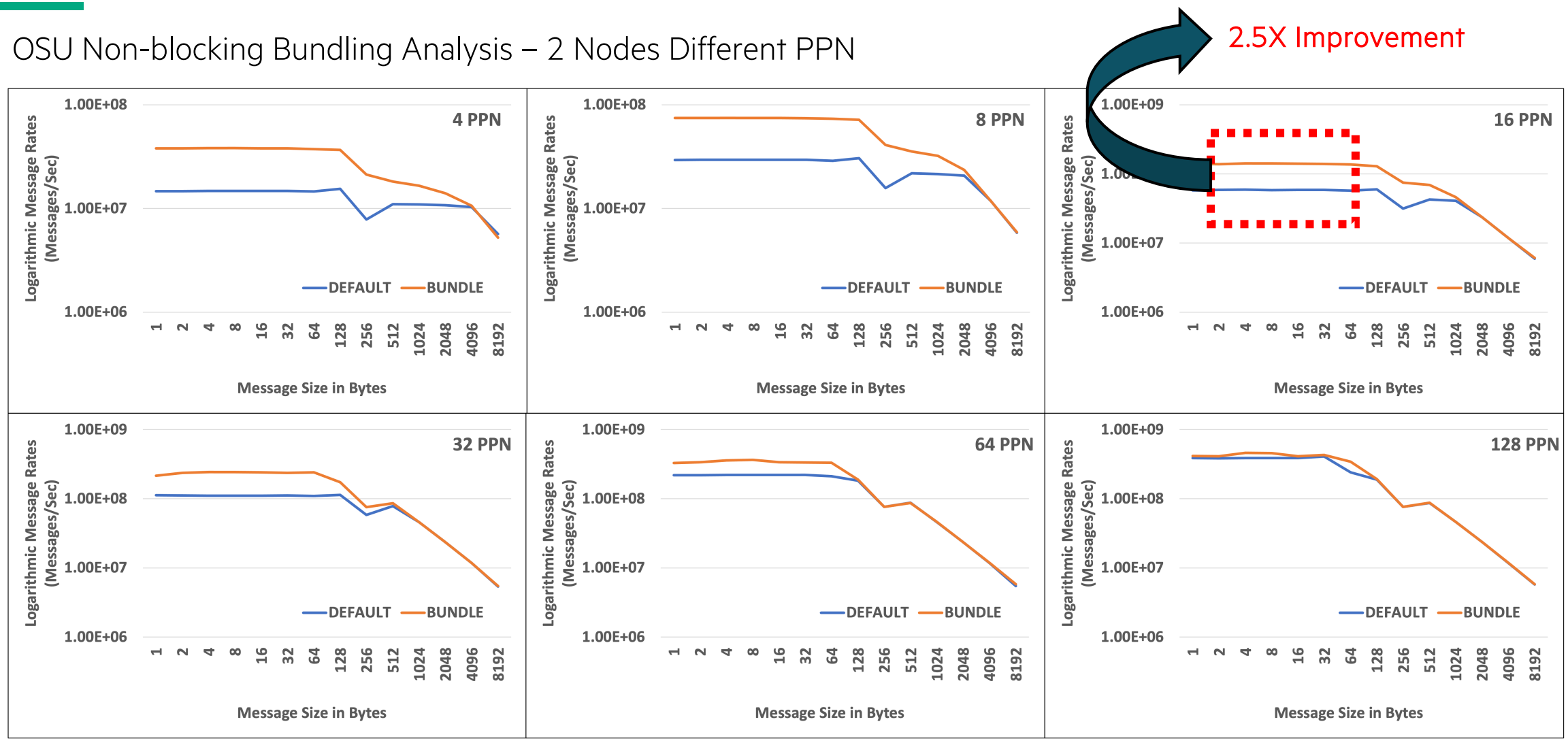
```
shmemx_ctx_session_start (SHMEM_CTX_DEFAULT,
SHMEM_SESSION_BUNDLE | SHMEM_SESSION_OP_PUT);

for (int i = 0; i < n; i++) {
        shmem_put_nbi (SHMEM_CTX_DEFAULT,
                       src + off[i], dst + off[i],
                       nelems, i);
}

shmemx_ctx_session_stop (SHMEM_CTX_DEFAULT);
shmem_quiet();
```

SLINGSHOT 11 NIC FEATURE – BUNDLING ANALYSIS

- OSU Non-blocking Bundling Analysis – 2 Nodes Different PPN



TRIGGERED COMMUNICATION OPERATIONS

- Deferred execution semantics
  - Event enqueued in the command queue list but deferred execution
  - Executed when certain conditions are satisfied

- Early thoughts
  - Our early experience is in using triggered operations for implementing put-with-signal in OpenSHMEM
  - Performance impact
    - Allowed communication/computation overlap
    - But – resource constrains – required to bundle PWS ops to use the same network resource

- How to use it in MPI RMA
  - Implicit implementation usage
    - Trigger operations during synchronization or completion points
  - Explicit user control
    - Not sure whether this is necessary
    - Is a persistent MPI RMA operation-like feature useful?

OVERALL INFERENCE

- Data size and type of data buffer are critical for performance
  - Small-size messages in INJECT protocol category is data size sensitive
  - Large-size messages are always pushed to use DMA protocol
  - SW protocol selection module
    - Critical for source buffers in global or local heap memory

- Local completions can help to achieve better computation/communication overlap

- Bundling operations help use-cases with low PPN count
  - 8 PPN case shows 2.5X performance improvement
  - Drive better BW on low PPN case

- Triggered operations
  - Can be used implicitly
  - Need for explicit user interface is debatable

CONCLUSION

- Introduced and explored Slingshot 11 features that impacts one-sided communication operations

- Discussed on this presentation
  - RMA Protocol selection
  - Event completion semantics
  - Bundling operations

- What did we learn?
  - Slingshot 11 supports many knobs for performance tuning
  - Working to expose them in a user-accessible way
  - Adapting Slingshot 11 features for MPI RMA
    - MPI-RMA supports “most” of the features to expose Slingshot 11 specific features
    - Adapting these features is implementation design choices
    - Areas where we need updates includes – passing hints for bundling and completions

THANK YOU

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