Hewlett Packard
Enterprise

CHAPEL 1.24.1 RELEASE NOTES: INFINIBAND OPTIMIZATIONS

Chapel Team

April 15, 2021

INFINIBAND
Background

- Historically, we have focused primarily on improving performance for Cray networks
  - Intent was to ensure we had the right language features/semantics first, then prioritize other networks

- Recently, we have been focusing on improving performance for InfiniBand (IB) networks
  - We use the GASNet communication library with the ibv conduit to target InfiniBand (gasnet-ibv)

INFINIBAND OPTIMIZATIONS

Background

- Memory must be registered with the network in order to do one-sided GETs/PUTs (RDMA)
  - gasnet-ibv supports two registration modes:
    - Static: All memory is registered at startup—fast communication, but hurts NUMA affinity and leads to long startup times
    - Dynamic: Memory is registered at communication time—can add overhead, but good NUMA affinity and fast startup
- Chapel defaults to dynamic registration to get good NUMA affinity and fast startup times
  - We believe this is the right choice for most users getting started
    - Have recommended static registration to some users with certain communication-heavy idioms
  - Ideally, we just want to have one mode with no, or few, downsides
- Late in the 1.24 release cycle, we identified some pre-existing performance issues on InfiniBand at scale
  - Diagnosed the root causes, leading to improvements for both static and dynamic registration
    - These improvements motivated April's 1.24.1 release

INFINIBAND STATIC REGISTRATION IMPROVEMENTS

INFINIBAND STATIC REGISTRATION

Background and This Effort

Background: Registration will fault memory in if it hasn't been already

- gasnet-ibv static registration is a serial operation, which meant fault-in was serial
  - This was slow and resulted in poor NUMA affinity
  - In practice when allocating memory, the allocation would live on a single NUMA domain, limiting memory bandwidth

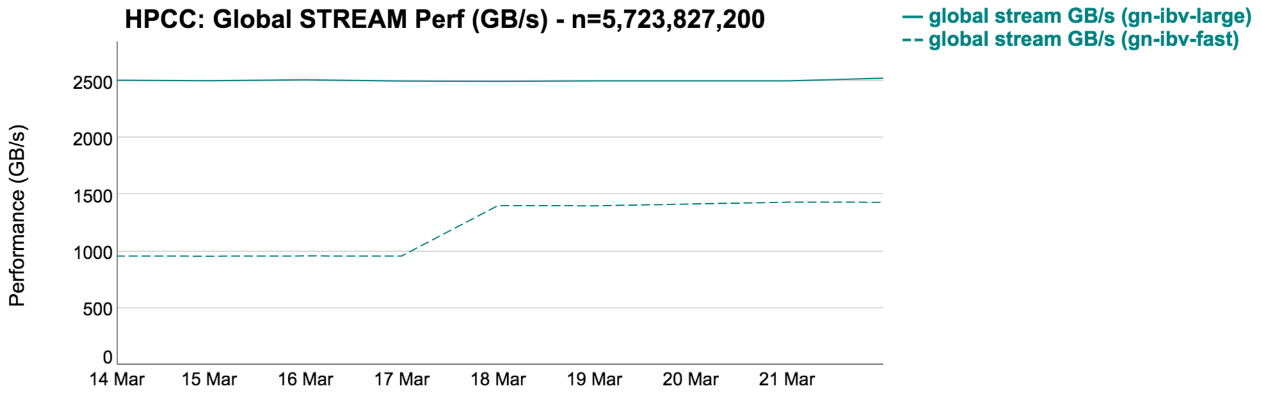
This Effort: Parallelize and interleave memory fault-in prior to registration

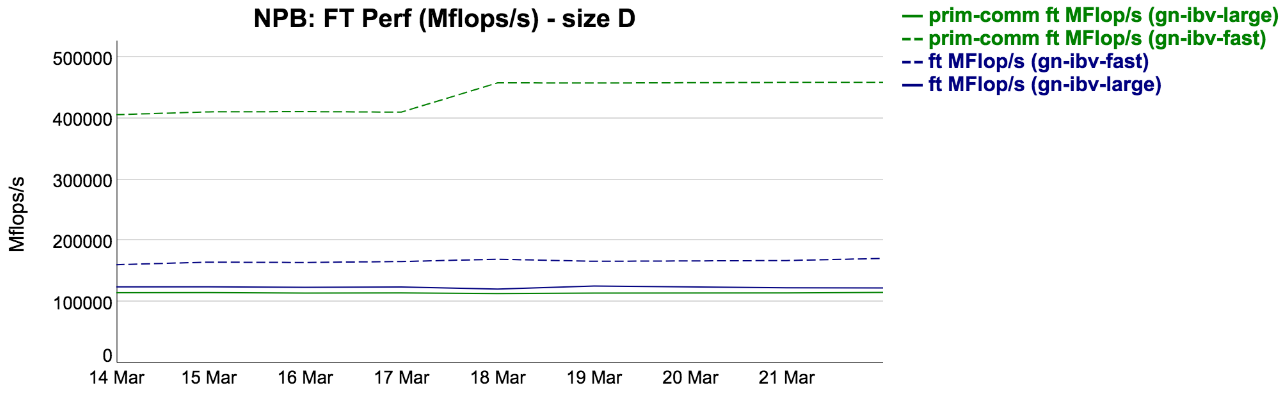
- Interleaving improves memory bandwidth by spreading memory accesses across NUMA domains
- Parallelizing speeds up fault-in time

INFINIBAND STATIC REGISTRATION

Impact

- Improved performance for NUMA-sensitive codes under static registration (gn-ibv-fast)

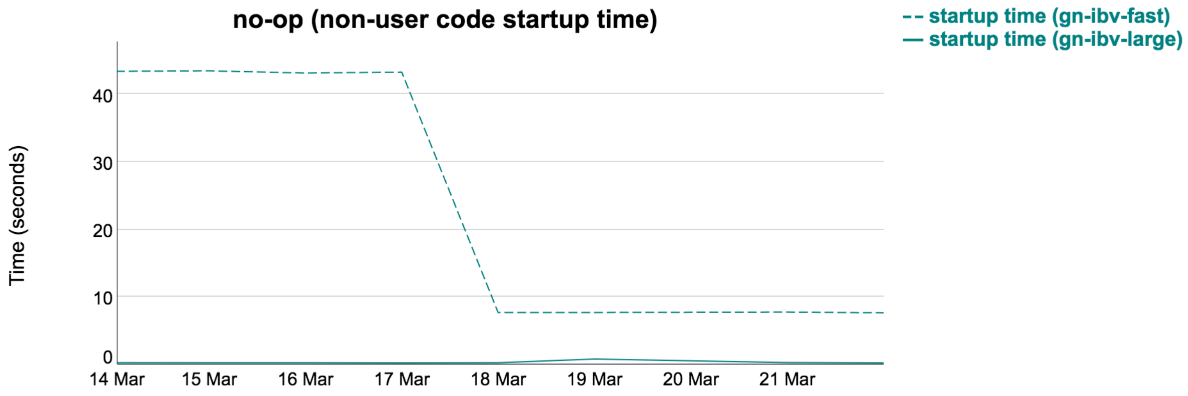




INFINIBAND STATIC REGISTRATION

Impact

- Faster startup time



- Startup time is faster than before, but still linear with respect to the amount of memory
  - On nodes with 1 TB of memory, startup takes ~60 seconds
    - Most of this time is spent registering memory, not faulting it in
    - May be able to improve this, though static registration will always have more startup overhead compared to dynamic

INFINIBAND DYNAMIC REGISTRATION IMPROVEMENTS

INFINIBAND DYNAMIC REGISTRATION

Background and This Effort

Background: gasnet-ibv dynamic registration only registers memory at communication time

- Results in fast startup, but registration cost can limit communication performance
- NUMA affinity is based on user first-touch rather than as a side-effect of registration
- Requires tracking which memory regions are currently registered

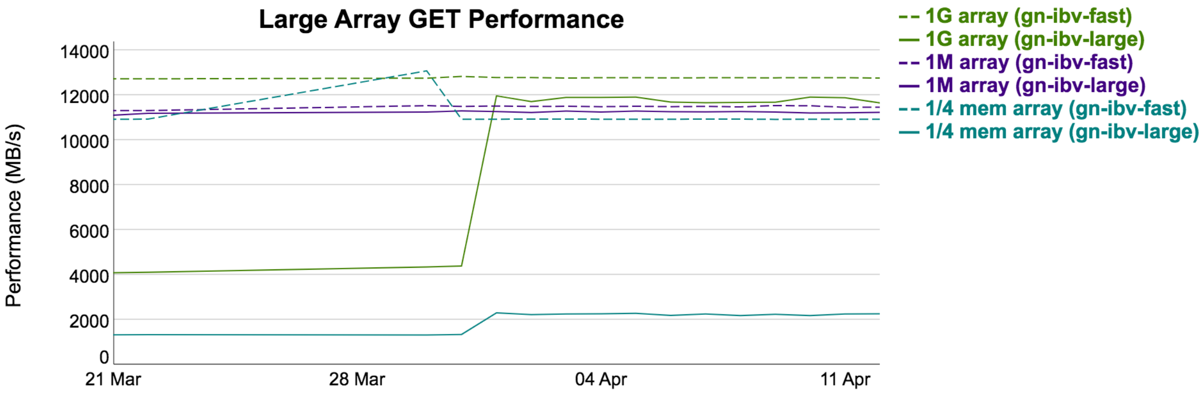
This Effort: Identified bottleneck in registration tracking code that limited performance and scalability

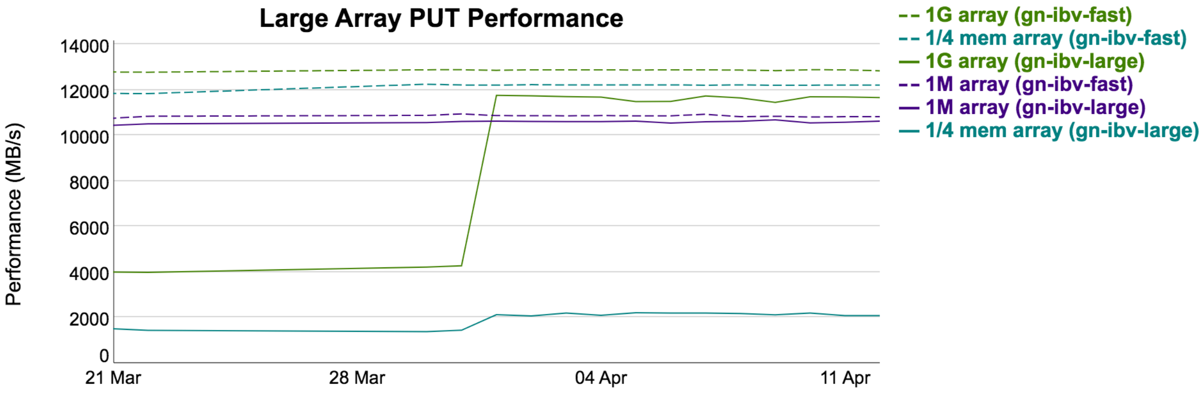
- Core issue was that we were running out of dynamic registration entries
  - Number of entries was hard-coded to what older generation networks could support
- Collaborated with the GASNet team to resolve this issue
  - Number of entries is now based on execution-time query of hardware capabilities

INFINIBAND DYNAMIC REGISTRATION

Impact

- Significant performance improvements for codes with large point-to-point communication patterns

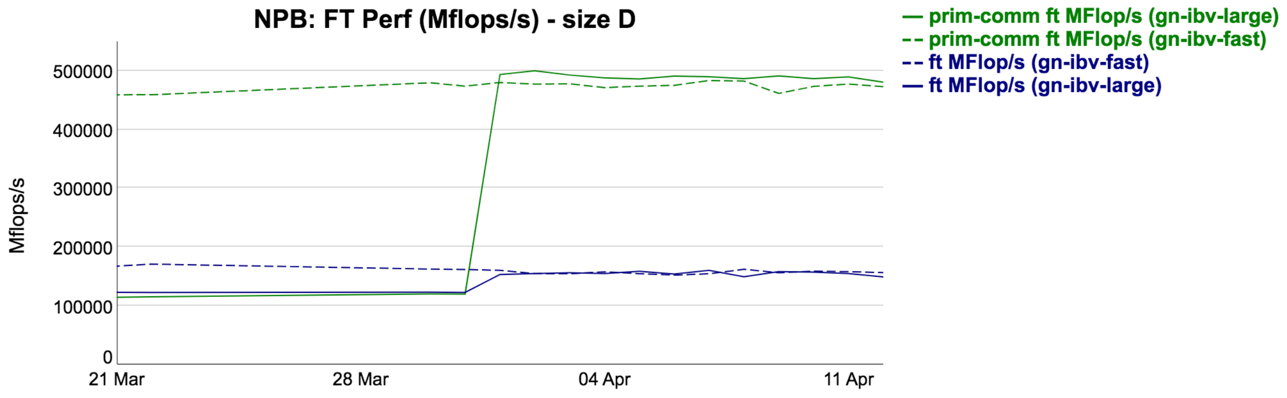


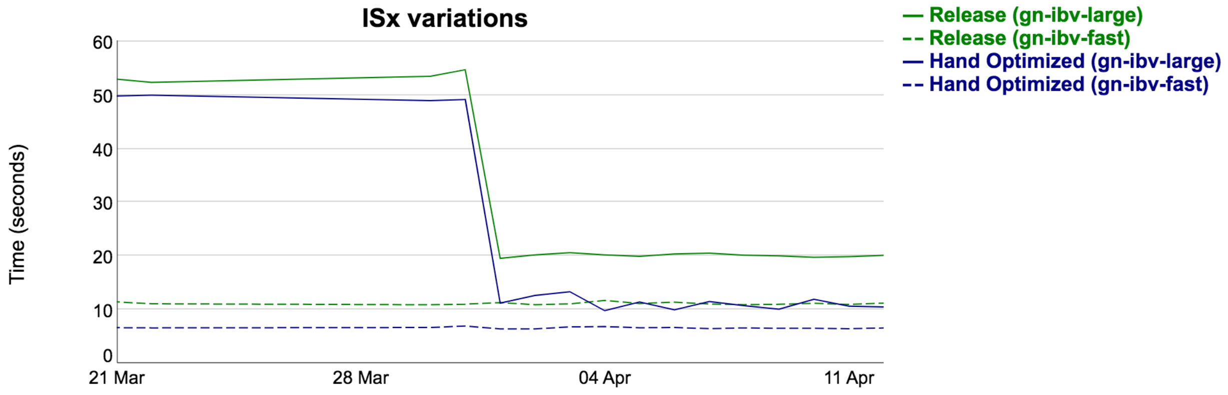


INFINIBAND DYNAMIC REGISTRATION

Impact

- Significant performance improvements for codes with all-to-all communication patterns



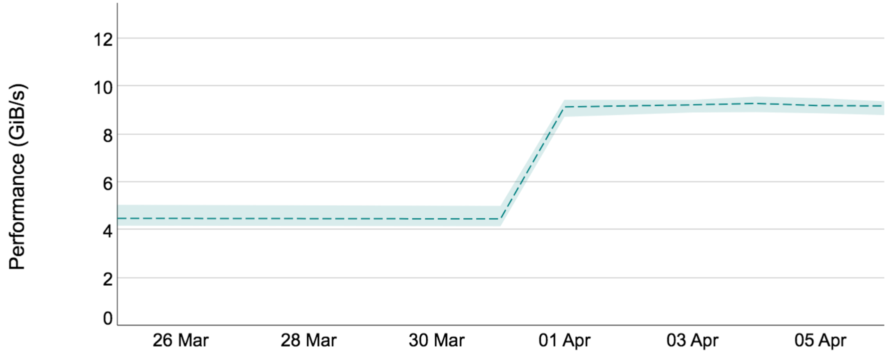


INFINIBAND DYNAMIC REGISTRATION

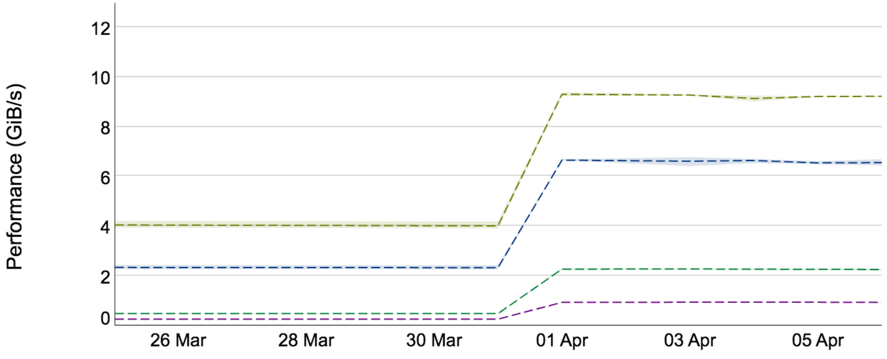
Impact

- Significant performance improvements for Arkouda

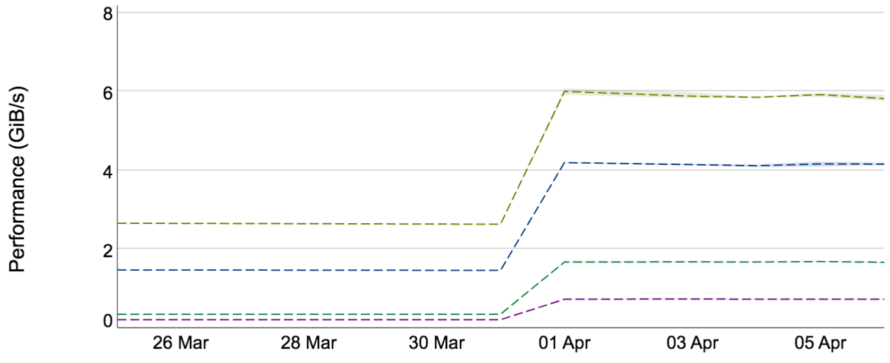
Argsort Performance



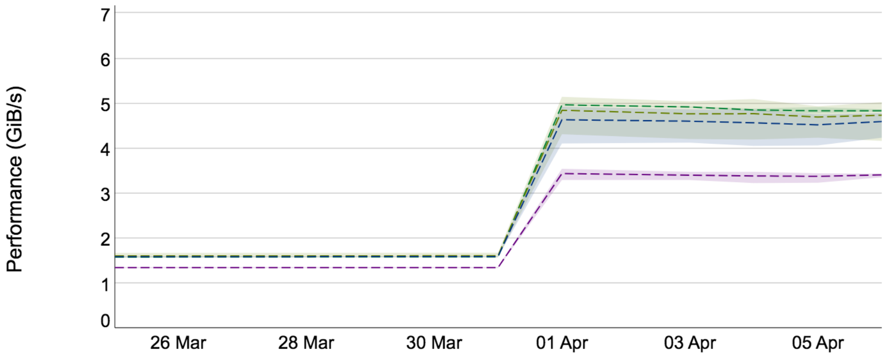
Coargsort Performance



Groupby Performance



Set Operations Performance



INFINIBAND OPTIMIZATIONS

Next Steps

- Explore ways to speed up static registration, possibly by parallelizing it
  - Consider supporting a mode that runs a process per NUMA domain

- Continue to improve dynamic registration performance
  - ISx and some other communication-intensive applications still lag behind static registration

- Look at using On-Demand-Paging (ODP) as an alternative registration mechanism
  - Hardware/firmware takes care of registration on-demand rather than tracking in software
  - Current prototype hangs
    - Needs more investigation and collaboration with the GASNet team

- Investigate experimental ucx conduit
  - Unified Communication X (UCX) is likely the future for targeting InfiniBand with GASNet
  - We have done preliminary testing and want to track ucx as upstream support becomes more stable

THANK YOU

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