Runtime and Third-party Changes

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Outline

● ‘ugni’ Comm Layer: Register Arrays Dynamically
● Other ‘ugni’ Comm Layer Improvements
● ‘gasnet’ Comm Layer: Enable Multi-domain
● Other Runtime Improvements
● Other Third-party Improvements
‘ugni’ Comm Layer: Register Arrays Dynamically
‘ugni’ Dynamic Registration: Background

- ‘ugni’ comm produced poor NUMA memory affinity:
  1. Comm layer acquired contiguous chunk of memory to serve as heap
  2. Comm layer registered heap with NIC
     • Most/all of heap ended up on NUMA domain 0, which is closer to NIC
  3. Comm layer passed heap base+size to mem layer to manage
     • Array allocations were typically entirely on one NUMA domain

Diagram:
- poor NUMA locality
- someArray
- registered heap
- most heap pages on NUMA 0
- some heap pages on NUMA 1

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‘ugni’ Dynamic Registration: This Effort

- **Allocate arrays outside heap, register dynamically**

1. Array allocator calls `comm` layer to get non-heap memory

2. Array allocator initializes array in parallel, localizing it
   - First-touch semantics balances array localization across NUMA domains

3. Array allocator calls `comm` layer again, to register the memory

![Diagram showing NUMA 0 and NUMA 1 with a separately registered array and good NUMA locality. The diagram also indicates a much smaller registered heap.](image-url)
‘ugni’ Dynamic Registration: Impact

HPCC: STREAM-EP Perf (GB/s) - n=5,723,827,200

PRK Stencil Variations Perf
‘ugni’ Dynamic Registration: Status, Next Steps

Status:
- Only applies to “big” arrays (#hugepages >= #NUMA domains)
  - Smaller arrays and other things still come from the regular heap
- Some scaling issues with large #s of registered memory regions
- Awkward: when out of memory, alloc succeeds but init gets SIGBUS

Next Steps:
- Dynamically extend and register the heap itself
  - Gets NUMA affinity for things other than big arrays
- Improve scalability for registration broadcast and lookup
- Make use of recent kernel change to avoid SIGBUS-on-OOM problem
- Investigate a full-blown registration caching implementation?
Other ‘ugni’ Comm Layer Improvements
Reduce Default Heap Size

Background: Default heap size was 2/3 node memory
- Heap had to hold everything, including arrays
- Heap was not extendable

This Effort: Reduce default heap size to 16 gb
- With dynamic registration, arrays are allocated outside the heap
- Still not really extendable, but doesn’t need to be as big
- Major heap space driver: Qthreads stack pools

Impact: Much quicker program startup
- Don’t have to create as many heap pages up front

Next Steps: Extend heap dynamically, on demand
- This is work in progress, which just missed the release
Use Nonblocking Ops for Strided Transfers

Background: Strided transfers under-utilized the network
- Used for array assignments that have to be done as many chunks
- Were done simply: network op, wait for done, network op, wait, etc.

This Effort: Use nonblocking technique instead
- Initiate many network ops, then wait for all
- Reduces time-to-initiate

Impact: Limited, not visible in regular nightly perf testing
- ~2x improvement on a feature-specific test, ~5% on PRK stencil

Next Steps: Probably only background efforts
- At this time few codes seem sensitive to strided transfer performance
‘gasnet’ Comm Layer: Enable Multi-domain
‘gasnet’ Multi-domain: Background and Effort

**Background:** ‘ugni’ comm significantly outperforms ‘gasnet’
- Especially for applications with a high degree of comm concurrency

**This Effort:** Enable GASNet’s multi-domain feature
- Improves performance of parallel RDMA operations
  - aries/gemini specific feature
  - similar to what ugni does by default
‘gasnet’ Multi-domain: Impact

**Impact:** Significantly improved ‘gasnet’ aries performance

- Though still lagging behind ‘ugni’

![Graphs showing performance metrics over time](image-url)
Next Steps: Continue to improve ‘gasnet’ comm performance

- Take advantage of dynamic registration for correct affinity
- Work with the GASNet team to explore other optimizations
- Track and explore GASNet-EX
  - add support for network atomics with GASNet when that comes online
Other Runtime Improvements
Other Runtime Improvements

- **Launcher changes:**
  - Added a gasnetrun_psm launcher for running on OmniPath
    - Contributed by Barry Moore
  - Fixed bugs in pbs-gasnetrun_ibv and slurm-based launchers

- **Retired ‘muxed’ tasking layer, deprecated in last release**
Other Third-party Improvements
Other Third-party Improvements

- Updated compiler to work with newer LLVM versions
- Switched LLVM back-end to use version 4.0.1 by default
- Updated GASNet to version 1.30.0
- Updated hwloc to version 1.11.8
- Updated GMP to version 6.1.2
- Updated RE2 to 2017-07-01
- Augmented third-party Makefiles to support auto-rebuild
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