Hewlett Packard Enterprise

Chapel 1.33 / 2.0 Release Notes: Runtime / Portability / Performance

Chapel Team

December 14, 2023 / March 21, 2024

Outline

Co-locale Improvements

Co-locales
Background

- Traditional Chapel multi-locale configuration:
  - One locale per node
  - Multithreading across cores in a locale
  - One NIC per locale

- Modern hardware performs best with a process per socket or even NUMA domain
  - High cost of getting NUMA affinity wrong
  - Benefit of targeting multiple NICs using distinct processes

Generalized Co-locales
Background and This Effort

Background:

- Previously, supported only one co-locale configuration
  - One locale per socket
  - NICs must be in sockets

This Effort:

- Allow one locale per socket, NUMA domain, L3 cache, or core
  - Also support simple partitioning of cores between the co-locales

- Automatically bind locales to architectural features
  - Option “-nl 1x2” will run each co-locale in its own socket on a node with two sockets
  - Option “-nl 1x8” will run each co-locale in its own NUMA domain on a node with eight NUMA domains
  - Option “-nl 1x6” will run each co-locale on 1/6 of the cores if no architectural feature has six instances

Generalized Co-locales

Impact

Impact: Improved NUMA affinity

- Stream benchmark results (no communication)

Configuration	GB/s	Improvement	Feature
-nl 2	357	N/A	N/A
-nl 2x2	460	28.9%	Socket
-nl 2x8	466	30.5%	NUMA
-nl 2x16	470	31.7%	L3 cache
“first touch”	470	31.7%	N/A

- Measured on dual-socket node, Milan CPUs, 64 cores/CPU

Generalized NIC Selection

Background, This Effort, and Next Steps

Background: Previously, bound each co-locale to the NIC in its socket

This Effort:

- Bind an arbitrary number of co-locales to NICs, possibly not in sockets
- Greedy algorithm:

Repeat

    Create distance matrix between all unbound co-locales and all NICs

    Repeat

        Bind co-locale and NIC with shortest distance

    Until all co-locales are bound to a NIC, or there are no more NICs

Until all co-locales are bound to a NIC

Next Steps: Evaluate impact on communication-intensive programs

Explicit Binding to Architectural Features

Background and This Effort

Background:

- By default, co-locales are implicitly bound to architectural features of which there are the same number
  - e.g., "-nl 2x2" will bind each co-locale to a socket on a dual-socket machine

This Effort:

- Added suffixes to explicitly force the binding to an architectural feature
  - e.g., "-nl 2x6numa" will bind each co-locale to a NUMA domain, leaving any extra domains unused
- Primarily useful for testing and benchmarking, e.g. "-nl 2x1s" to run a locale in one socket

Explicit Binding to Architectural Features
Status

Status: -nl argument accepts an optional suffix that specifies the binding

- E.g., “-nl 2x8numa”

Binding	Suffix
Socket	s or socket
NUMA domain	numa
L3 cache	llc
Core	c or core

Co-locales

Next Steps

- Evaluate impact of co-locales on large shared-memory systems like HPE Superdome Flex

- Shared-memory bypass
  - Co-locales on the same node communicate using shared memory, instead of the network
  - Requires moderate amount of coding
  - Minimal benefit if there isn’t intra-node communication or caching

- Automatically determine ideal number of co-locales
  - Requires extensive refactoring of the launchers

One Billion Row Challenge

One Billion Row Challenge

Background:

- The One Billion Row Challenge is a "fun exploration of how quickly 1B rows from a text file can be aggregated"
  - It became viral on social media; several implementations exist in various languages
  - It avoids measuring IO overhead by first preloading data onto a RAM disk
- For our purposes, we find it more interesting and practical to use for measuring and addressing IO overhead

This Effort: create a Chapel implementation focused on readability and parallelism

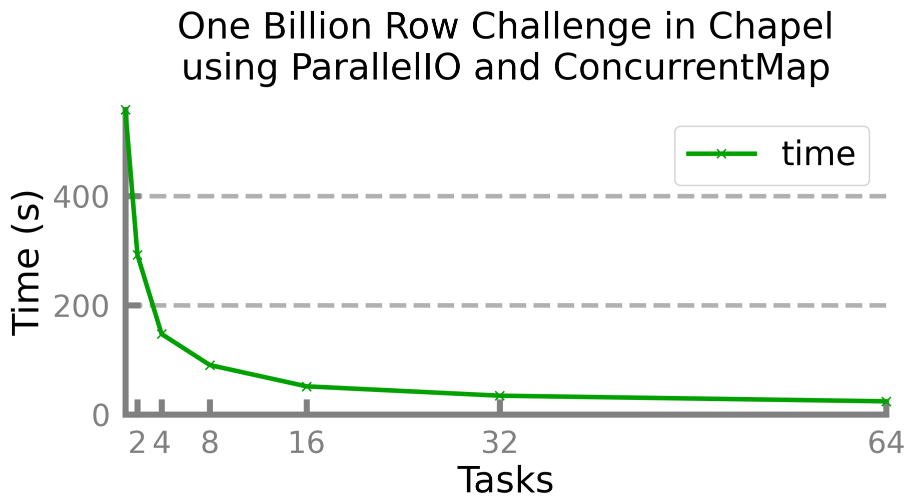
- We use the 'ParallelIO' and 'ConcurrentMap' package modules
- The implementation uses a simple 'forall' loop as well as a custom aggregator and deserialization functions
- This is what the main loop looks like:

```
var stats = new ConcurrentMap(bytes, tempData);
forall ct in readDelimited(fileName, t = cityTemp) with (var token = stats.getToken()) {
  stats.update(ct.city, new aggregator(ct.temp), token);
}
```

One Billion Row Challenge

Impact: the concise Chapel code performs well on a 64-core (AMD EPYC 7513) machine

- A naïve Python version takes 1390s (23m, 10s)
- A naïve, serial Chapel version takes 755s (12m, 35s)
- The parallel version further improves performance:



Tasks	Time (s)	Time (m:ss)
1	588	9:48
2	292	4:52
4	147	2:27
8	90	1:30
16	51	0:51
32	34	0:34
64	24	0:24

Next Steps:

- Create a multi-node (distributed) version
- Publish blog post about this (work-in-progress)

AWS Portability and Performance

AWS Portability
Background and This Effort

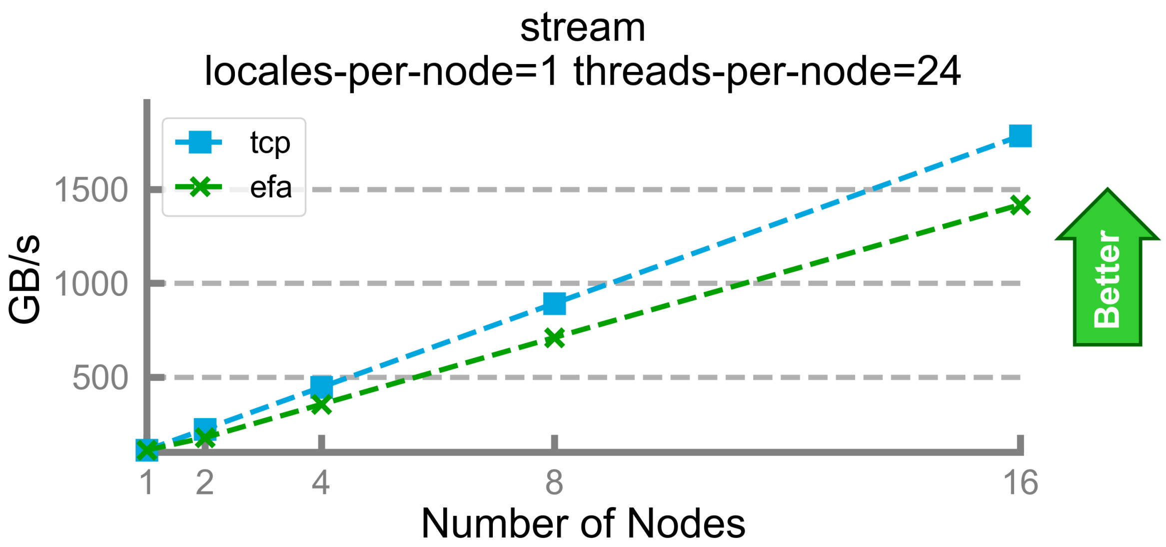
Background: Past uses of Chapel on AWS have been one-off efforts by heroic users or developers

This Effort:

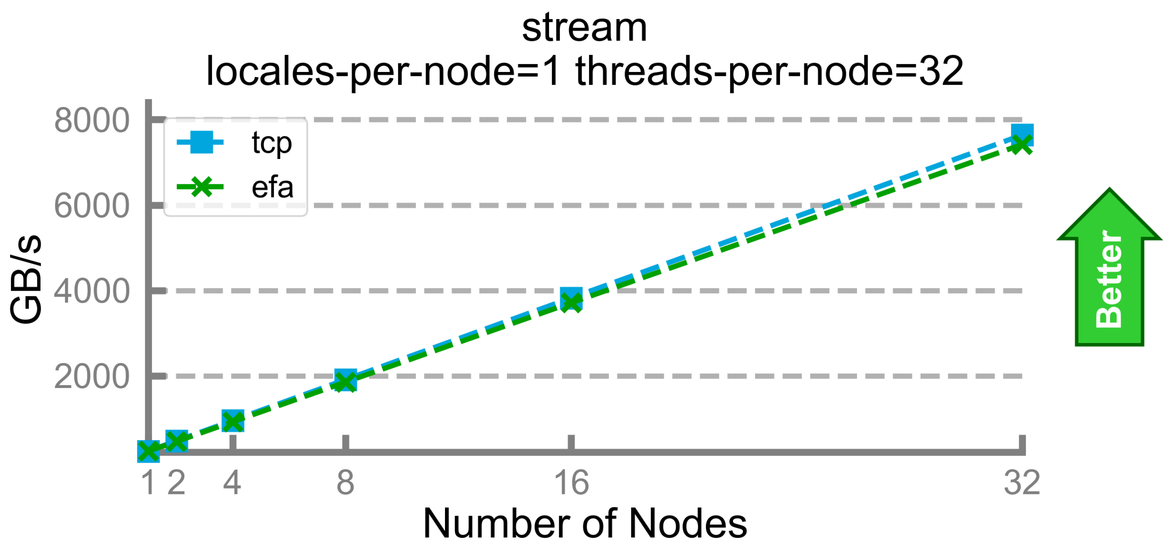
- Evaluated Chapel correctness and performance with AWS ParallelCluster
  - Allows users to create their own HPC-like clusters in the cloud
- Validated Arkouda correctness with AWS Parallel Cluster
- Refreshed Chapel AWS documentation
  - Provided step-by-step guide to use Chapel and AWS ParallelCluster
- Compared performance of different AWS networks
  - Ethernet (tcp)
  - Elastic Fabric Adapter (efa)

AWS
Performance

Intel 8252C (m5zn.12xlarge)



AWS Graviton3 (c7g.16xlarge)



AWS
Performance

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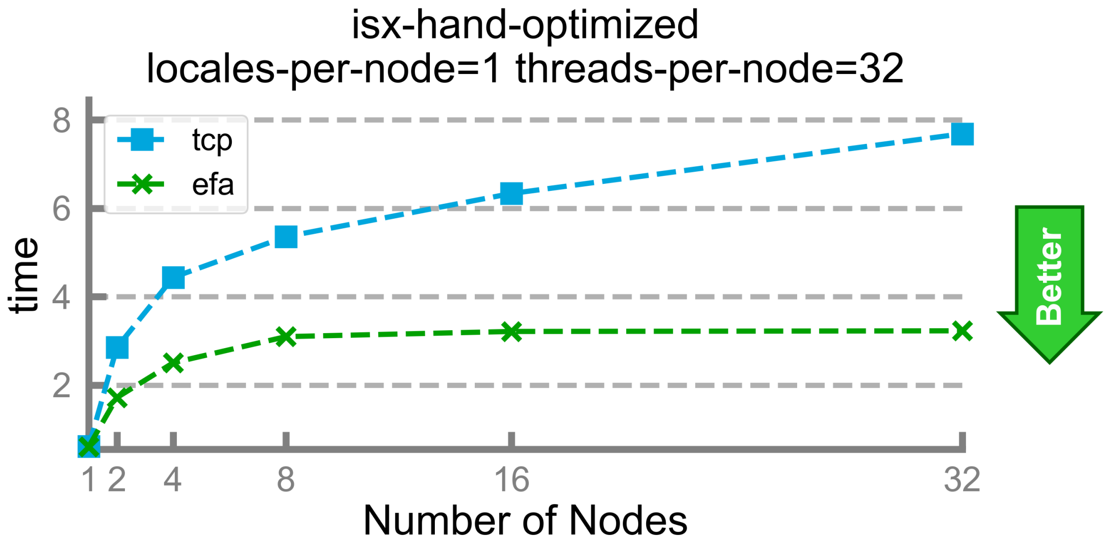

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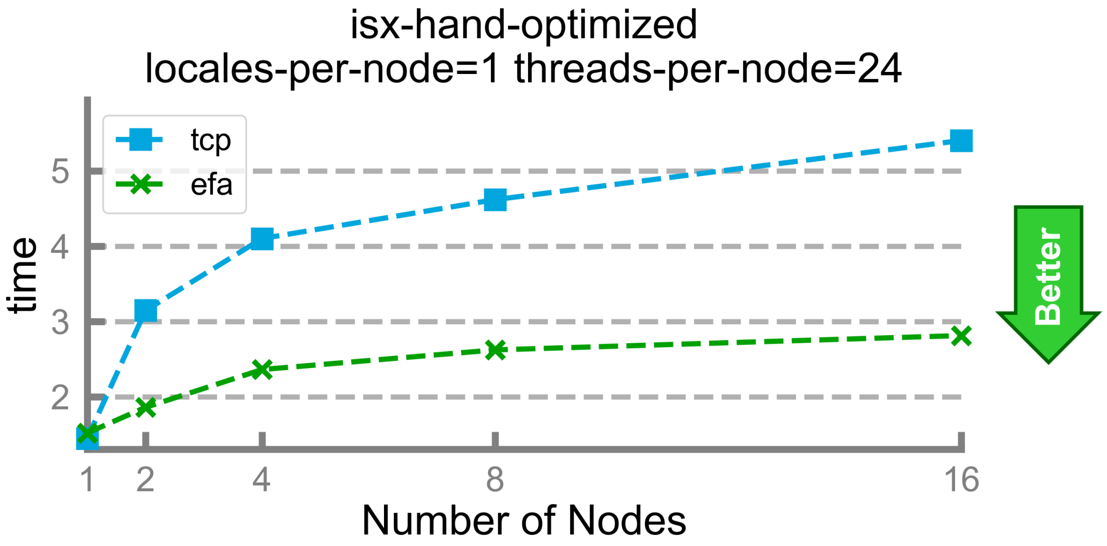

AWS
Performance

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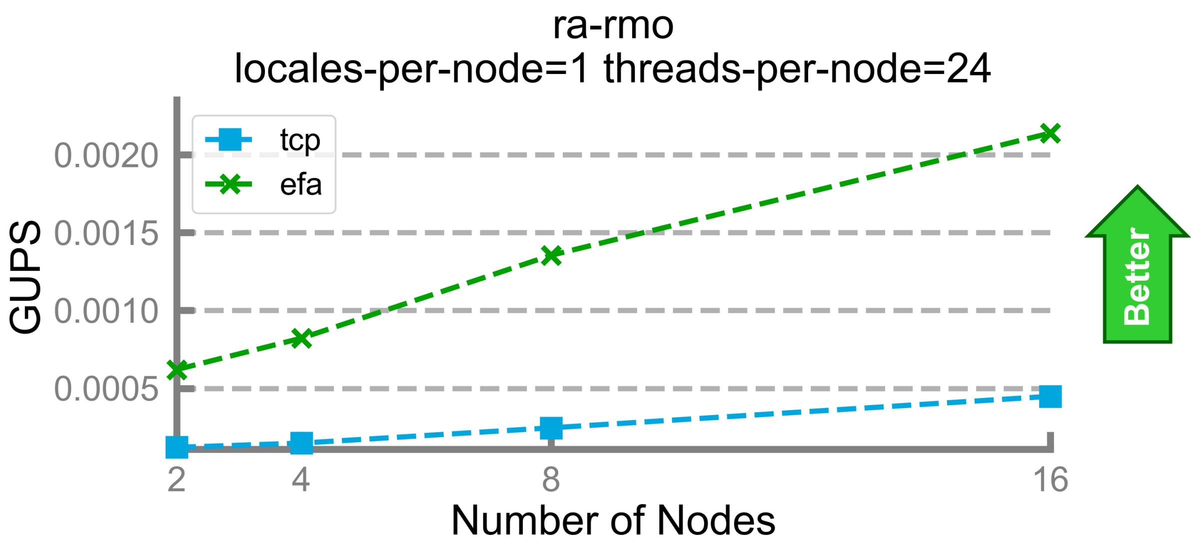

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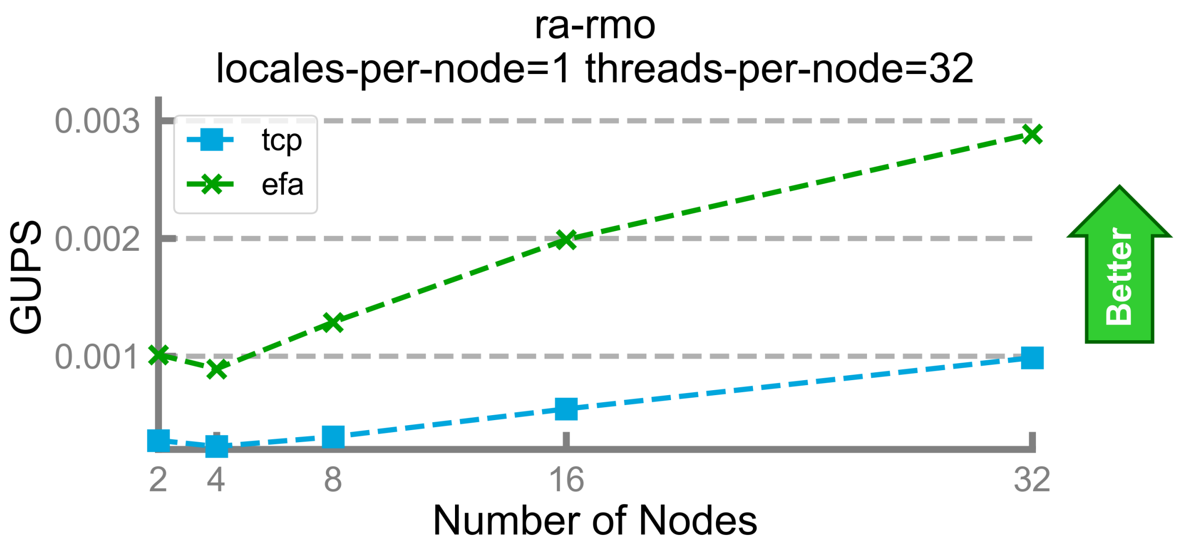

AWS
Next Steps

- AWS Packaging
  - Currently, the easiest way for users to use Chapel on AWS is to build from source

- Remove EFA memory restrictions
  - EFA heap registration is currently limited to 96GB per node

Other Improvements

Other Improvements

See the following sections in the CHANGES.md file for a full list of changes:

- Performance Optimizations / Improvements
- Runtime Library Changes
- Portability / Platform-specific Improvements
- Bug Fixes for the Runtime
- Launchers
- Developer-oriented changes: Platform-specific bug fixes
- Developer-oriented changes: Launcher Improvements

Thank you

https://chapel-lang.org
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