Portability and Third-Party Improvements

Chapel Team, Cray Inc.
Chapel version 1.10
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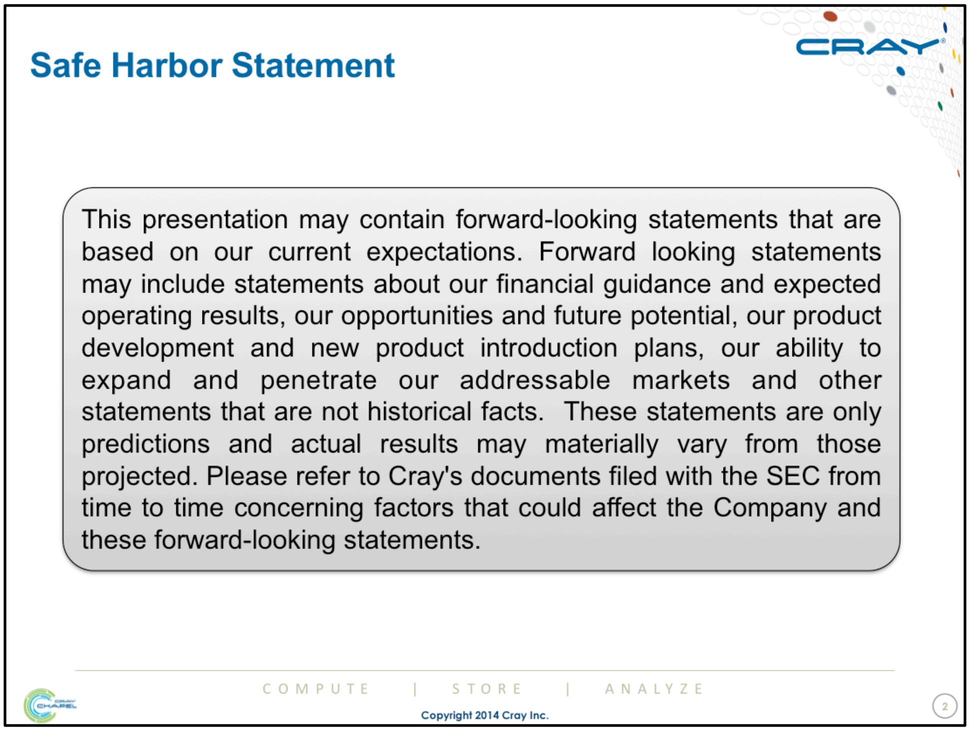

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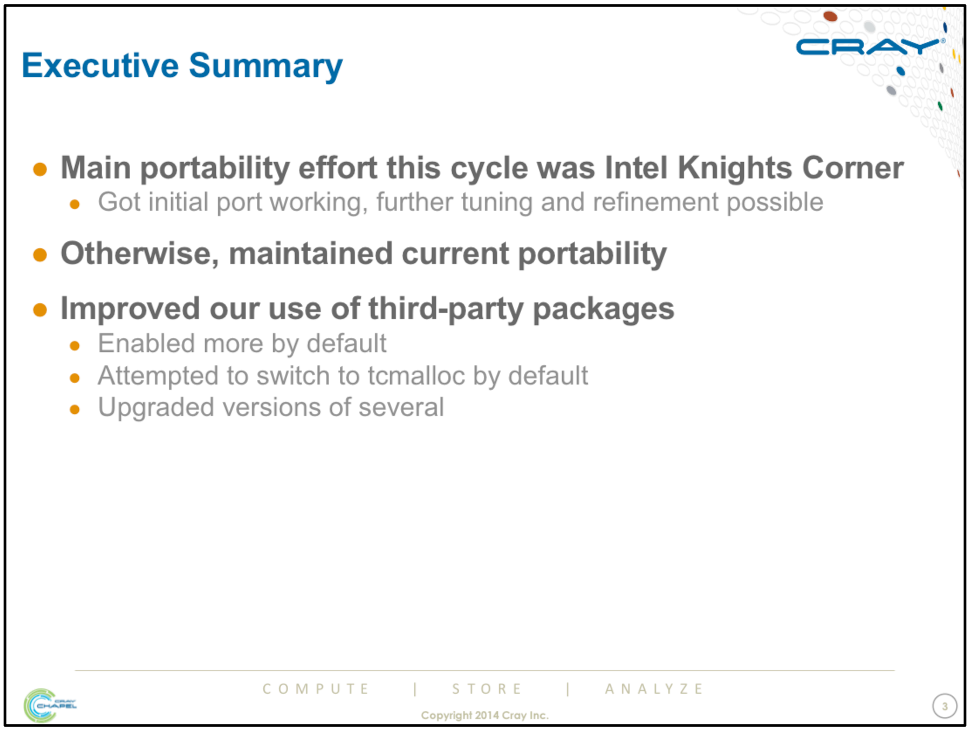
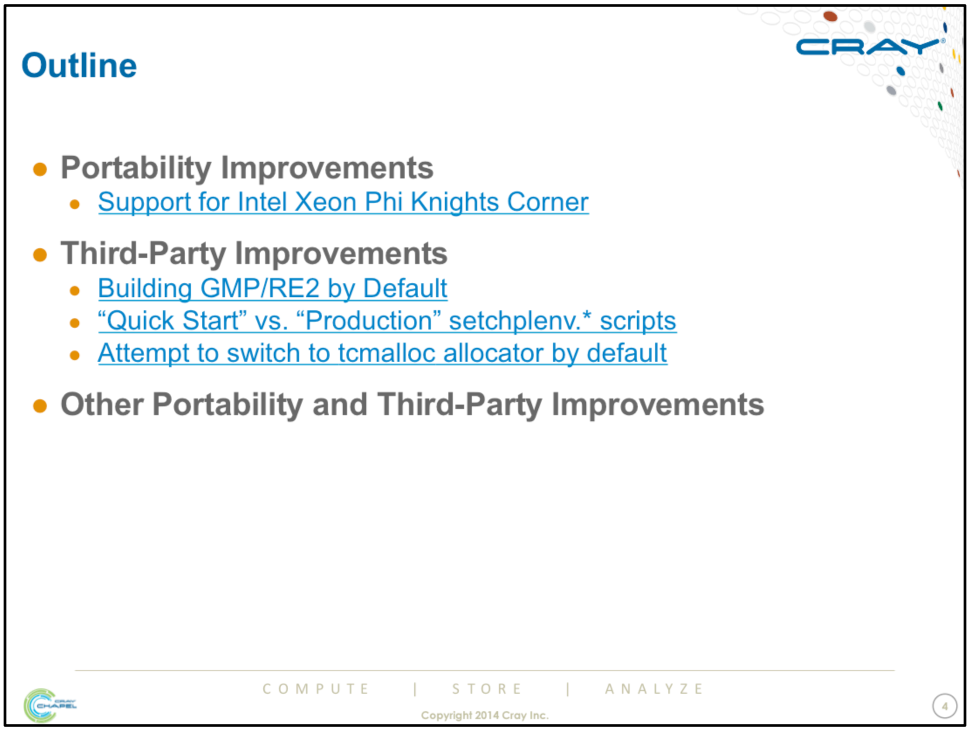


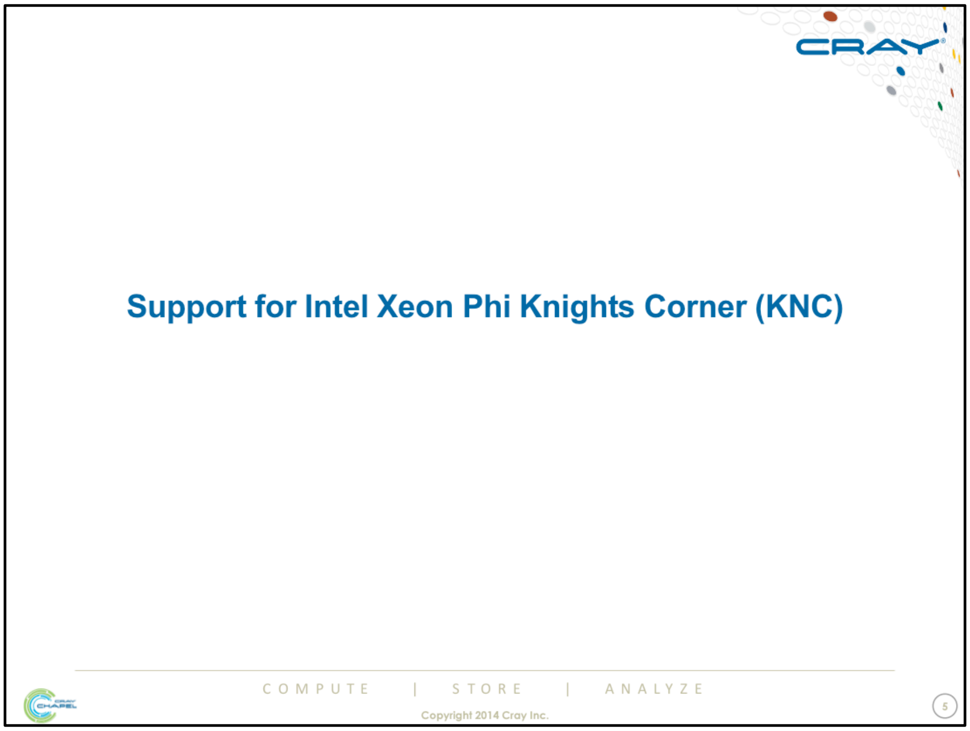
Executive Summary

- **Main portability effort this cycle was Intel Knights Corner**
  - Got initial port working, further tuning and refinement possible
- **Otherwise, maintained current portability**
- **Improved our use of third-party packages**
  - Enabled more by default
  - Attempted to switch to tcmalloc by default
  - Upgraded versions of several

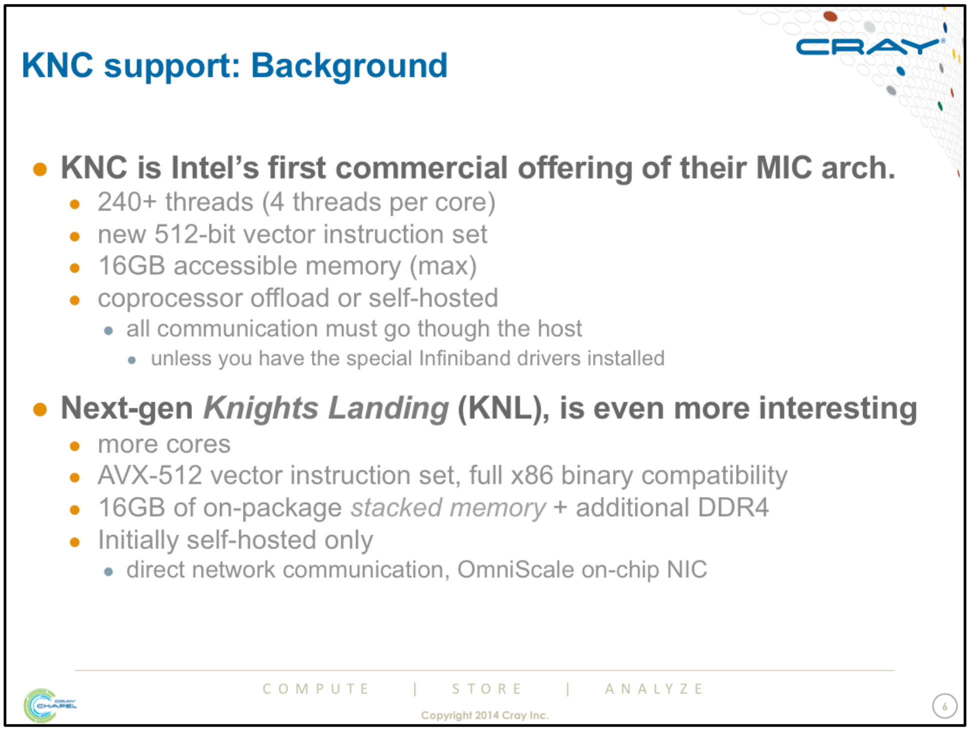


Outline

- **Portability Improvements**
  - Support for Intel Xeon Phi Knights Corner
- **Third-Party Improvements**
  - Building GMP/RE2 by Default
  - “Quick Start” vs. “Production” setchplenv.* scripts
  - Attempt to switch to tcmalloc allocator by default
- **Other Portability and Third-Party Improvements**

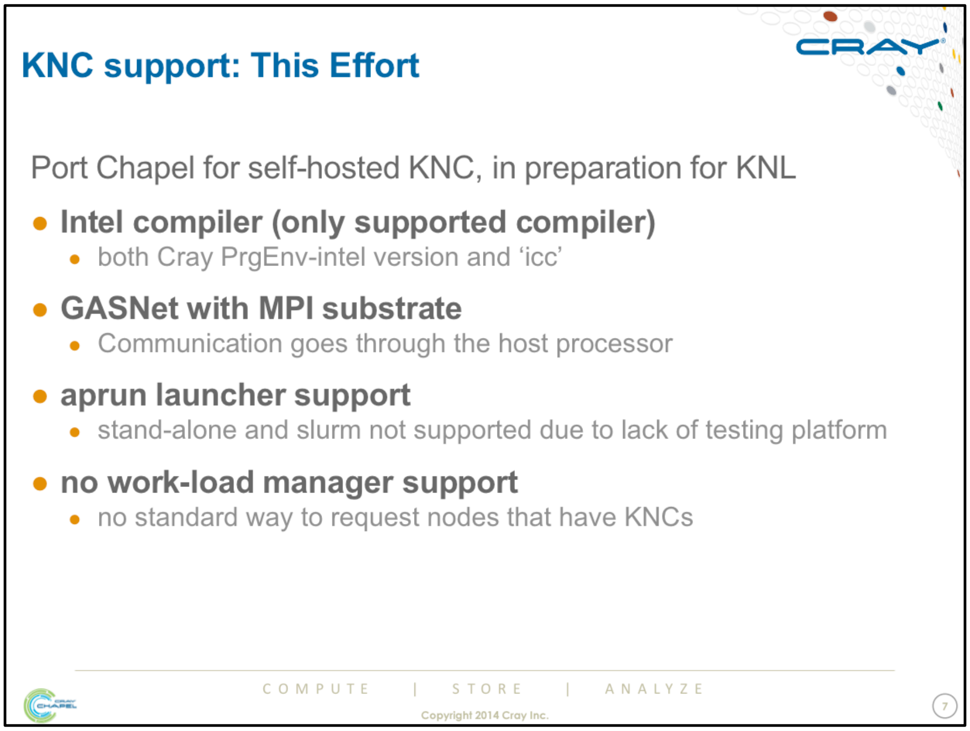


Support for Intel Xeon Phi Knights Corner (KNC)



KNC support: Background

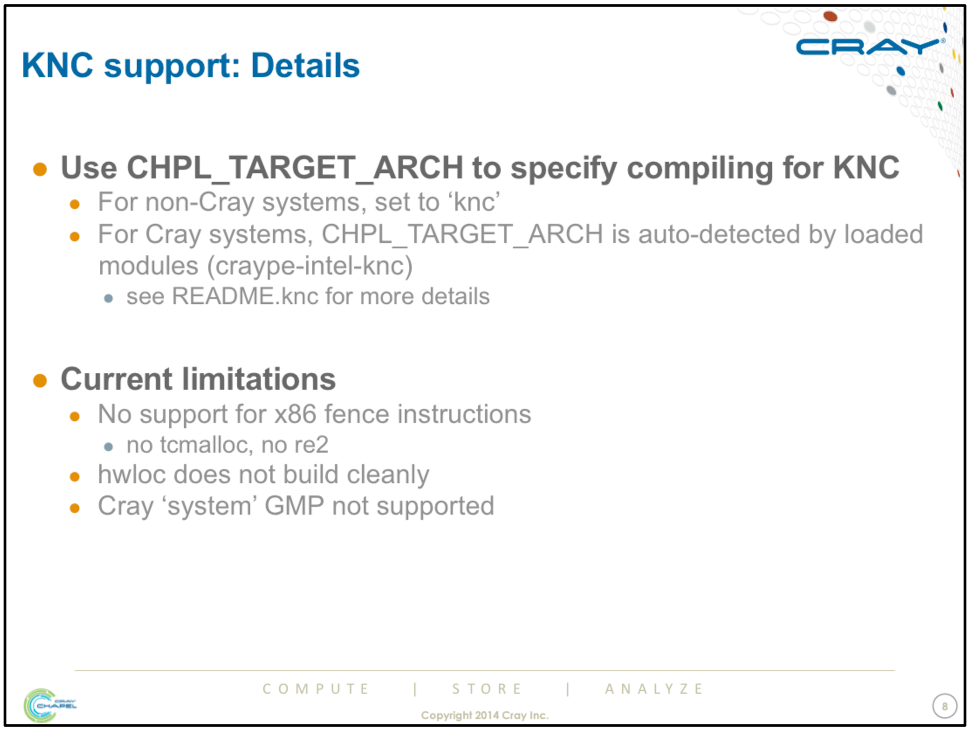
- **KNC is Intel's first commercial offering of their MIC arch.**
  - 240+ threads (4 threads per core)
  - new 512-bit vector instruction set
  - 16GB accessible memory (max)
  - coprocessor offload or self-hosted
    - all communication must go though the host
      - unless you have the special Infiniband drivers installed
- **Next-gen *Knights Landing* (KNL), is even more interesting**
  - more cores
  - AVX-512 vector instruction set, full x86 binary compatibility
  - 16GB of on-package *stacked memory* + additional DDR4
  - Initially self-hosted only
    - direct network communication, OmniScale on-chip NIC



KNC support: This Effort

Port Chapel for self-hosted KNC, in preparation for KNL

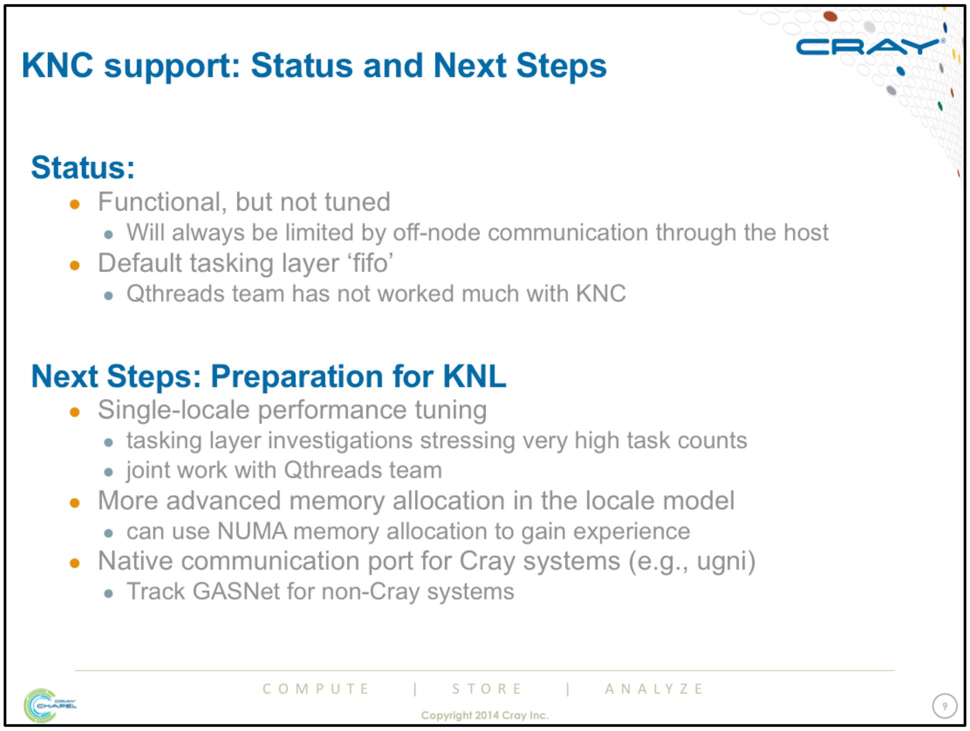
- **Intel compiler (only supported compiler)**
  - both Cray PrgEnv-intel version and 'icc'
- **GASNet with MPI substrate**
  - Communication goes through the host processor
- **aprun launcher support**
  - stand-alone and slurm not supported due to lack of testing platform
- **no work-load manager support**
  - no standard way to request nodes that have KNCs



KNC support: Details

- **Use CHPL_TARGET_ARCH to specify compiling for KNC**
  - For non-Cray systems, set to ‘knc’
  - For Cray systems, CHPL_TARGET_ARCH is auto-detected by loaded modules (craype-intel-knc)
    - see README.knc for more details

- **Current limitations**
  - No support for x86 fence instructions
    - no tcmalloc, no re2
  - hwloc does not build cleanly
  - Cray ‘system’ GMP not supported



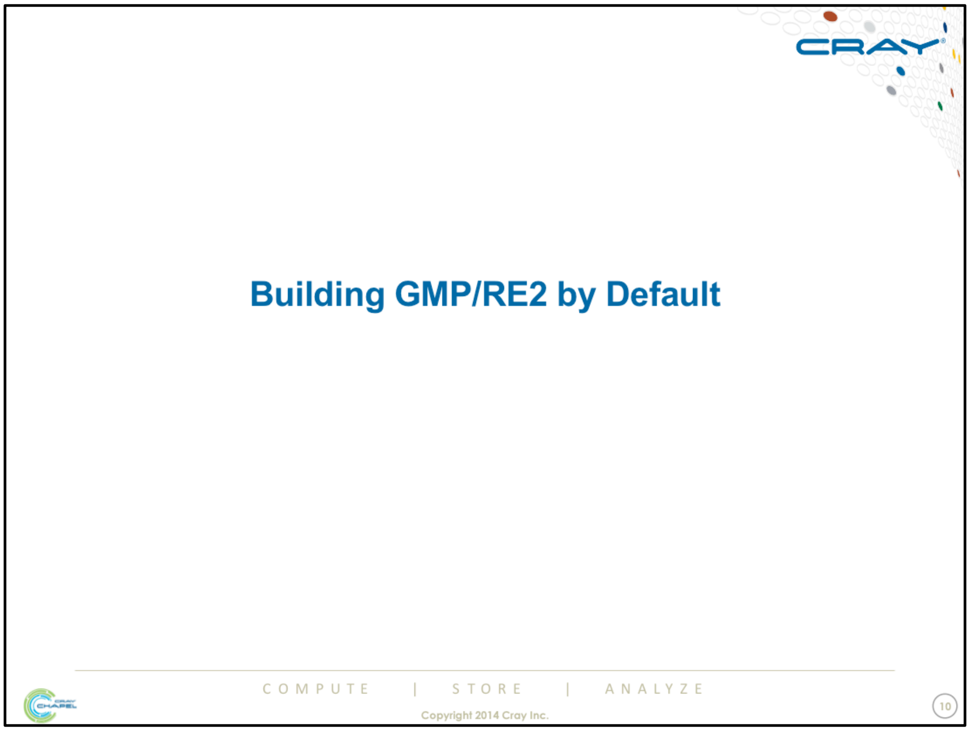
KNC support: Status and Next Steps

Status:

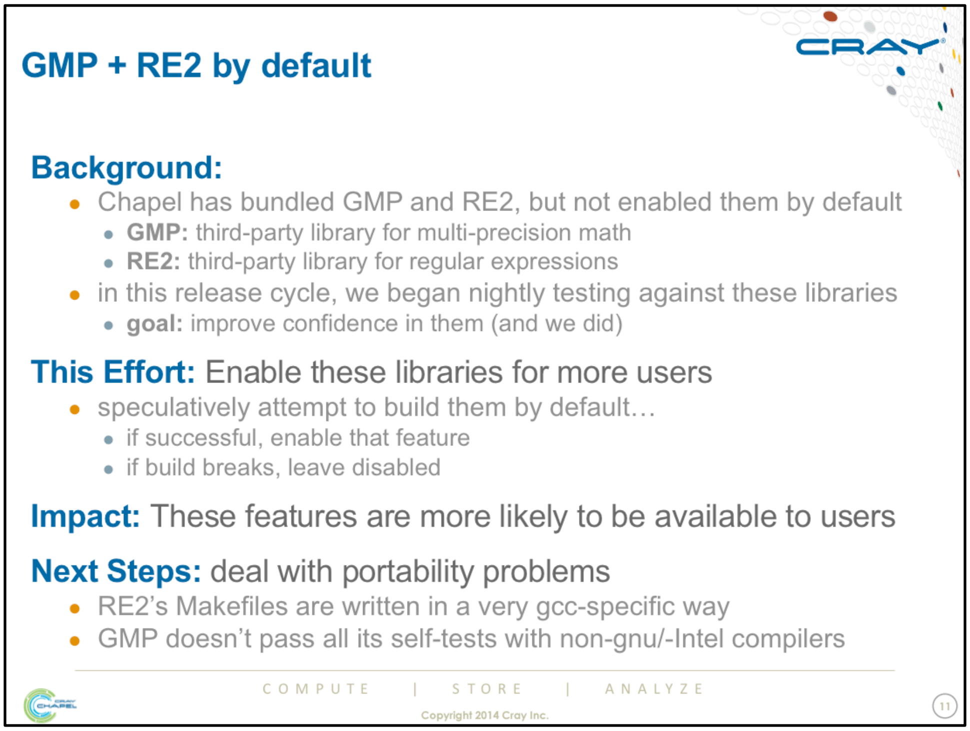
- Functional, but not tuned
  - Will always be limited by off-node communication through the host
- Default tasking layer ‘fifo’
  - Qthreads team has not worked much with KNC

Next Steps: Preparation for KNL

- Single-locale performance tuning
  - tasking layer investigations stressing very high task counts
  - joint work with Qthreads team
- More advanced memory allocation in the locale model
  - can use NUMA memory allocation to gain experience
- Native communication port for Cray systems (e.g., ugni)
  - Track GASNet for non-Cray systems



Building GMP/RE2 by Default



GMP + RE2 by default

Background:

- Chapel has bundled GMP and RE2, but not enabled them by default
  - **GMP:** third-party library for multi-precision math
  - **RE2:** third-party library for regular expressions
- in this release cycle, we began nightly testing against these libraries
  - **goal:** improve confidence in them (and we did)

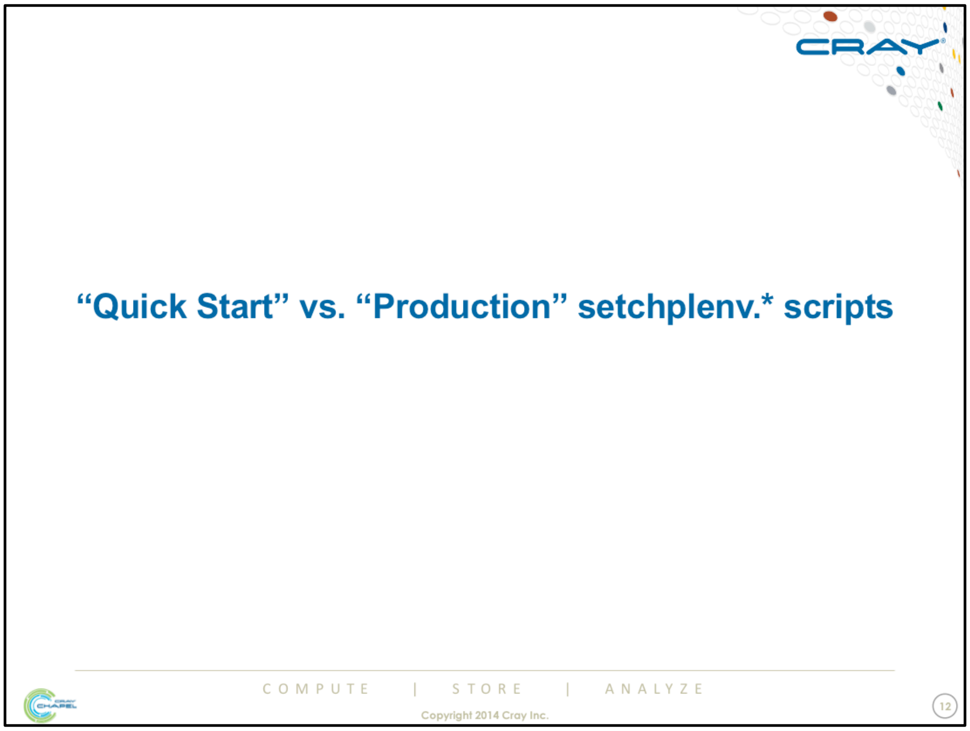
This Effort: Enable these libraries for more users

- speculatively attempt to build them by default…
  - if successful, enable that feature
  - if build breaks, leave disabled

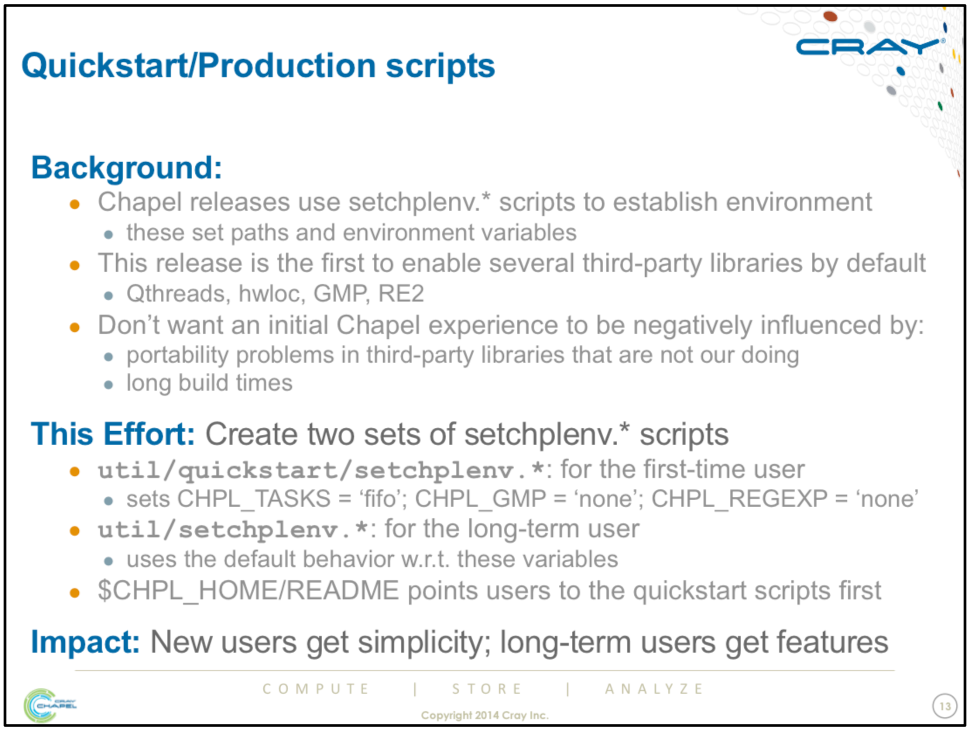
Impact: These features are more likely to be available to users

Next Steps: deal with portability problems

- RE2's Makefiles are written in a very gcc-specific way
- GMP doesn't pass all its self-tests with non-gnu/-Intel compilers



“Quick Start” vs. “Production” setchplenv.* scripts



Quickstart/Production scripts

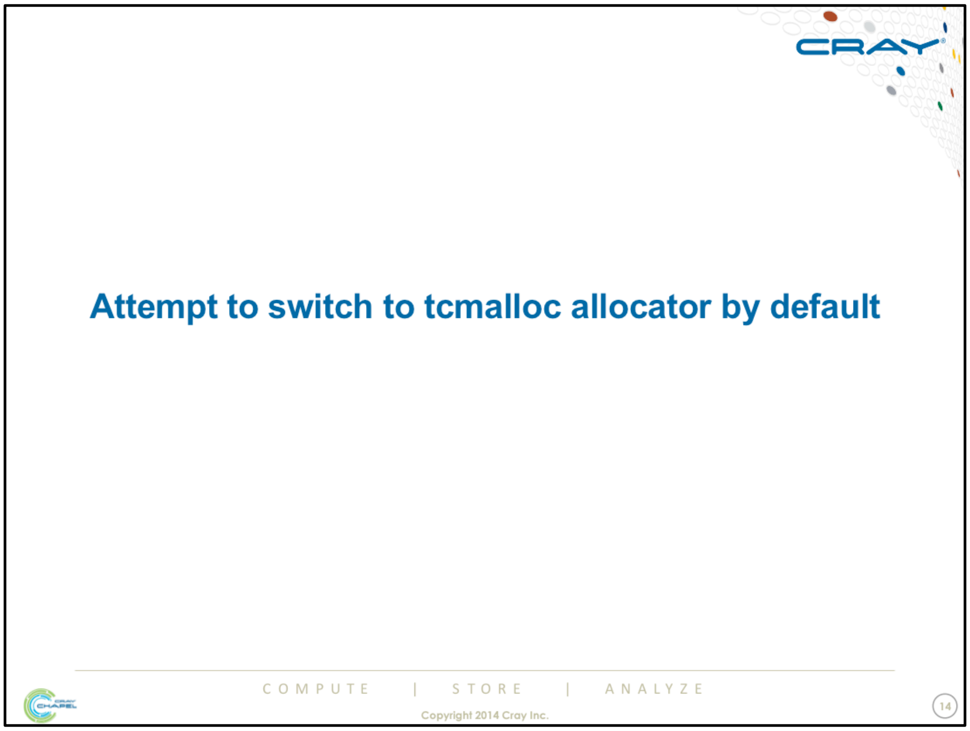
Background:

- Chapel releases use setchplenv.* scripts to establish environment
  - these set paths and environment variables
- This release is the first to enable several third-party libraries by default
  - Qthreads, hwloc, GMP, RE2
- Don’t want an initial Chapel experience to be negatively influenced by:
  - portability problems in third-party libraries that are not our doing
  - long build times

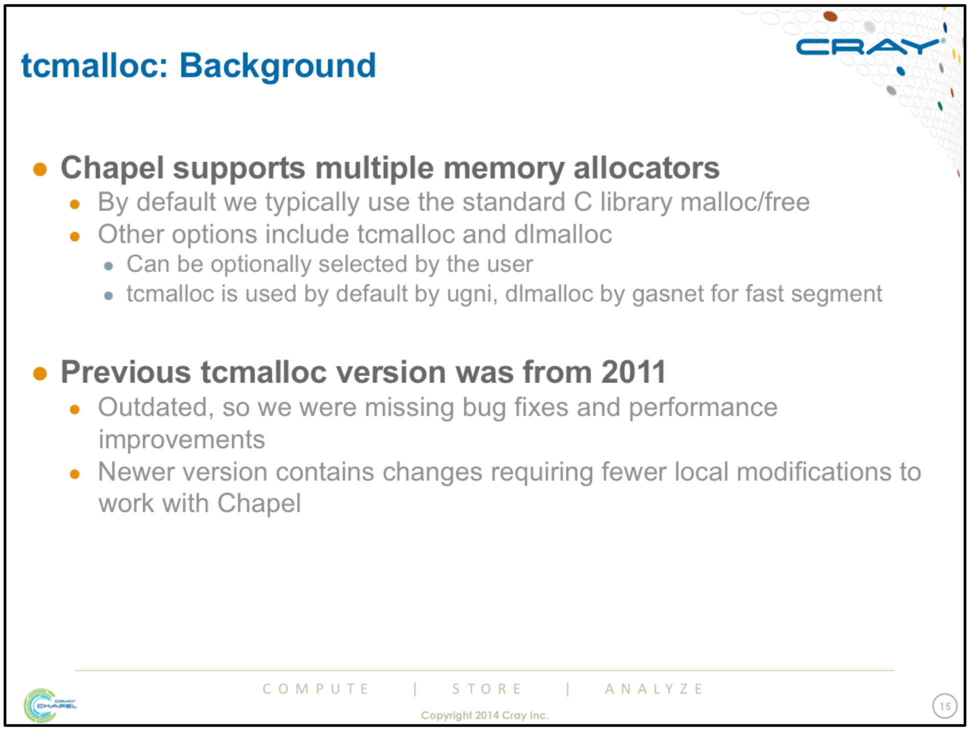
This Effort: Create two sets of setchplenv.* scripts

- `util/quickstart/setchplenv.*`: for the first-time user
  - sets CHPL_TASKS = ‘fifo’; CHPL_GMP = ‘none’; CHPL_REGEXP = ‘none’
- `util/setchplenv.*`: for the long-term user
  - uses the default behavior w.r.t. these variables
- $CHPL_HOME/README points users to the quickstart scripts first

Impact: New users get simplicity; long-term users get features

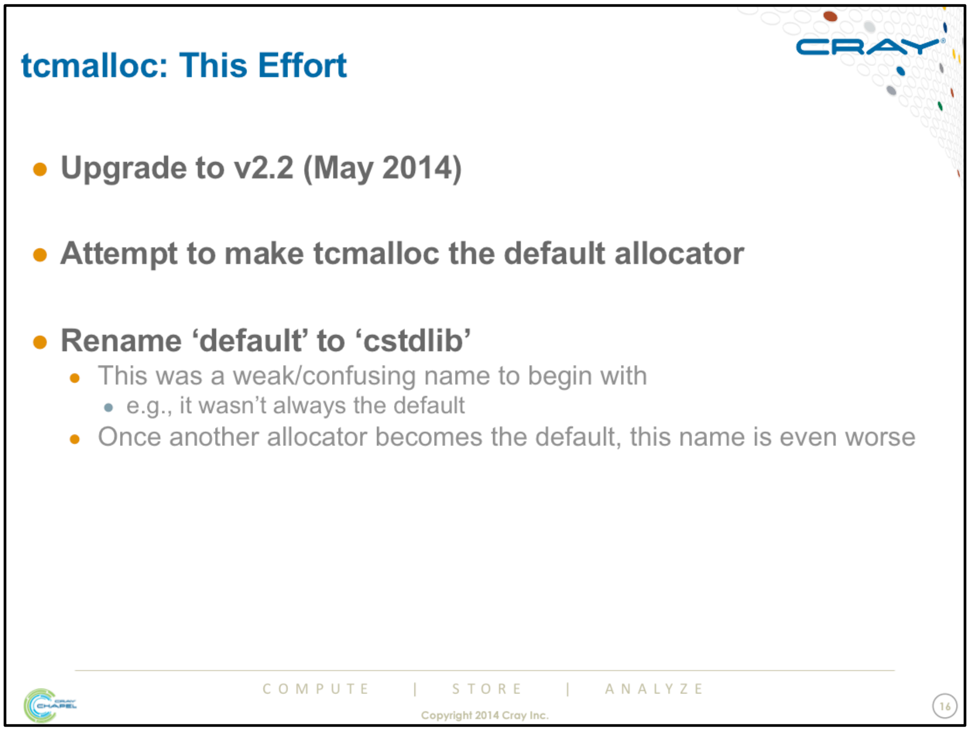


Attempt to switch to tcmalloc allocator by default



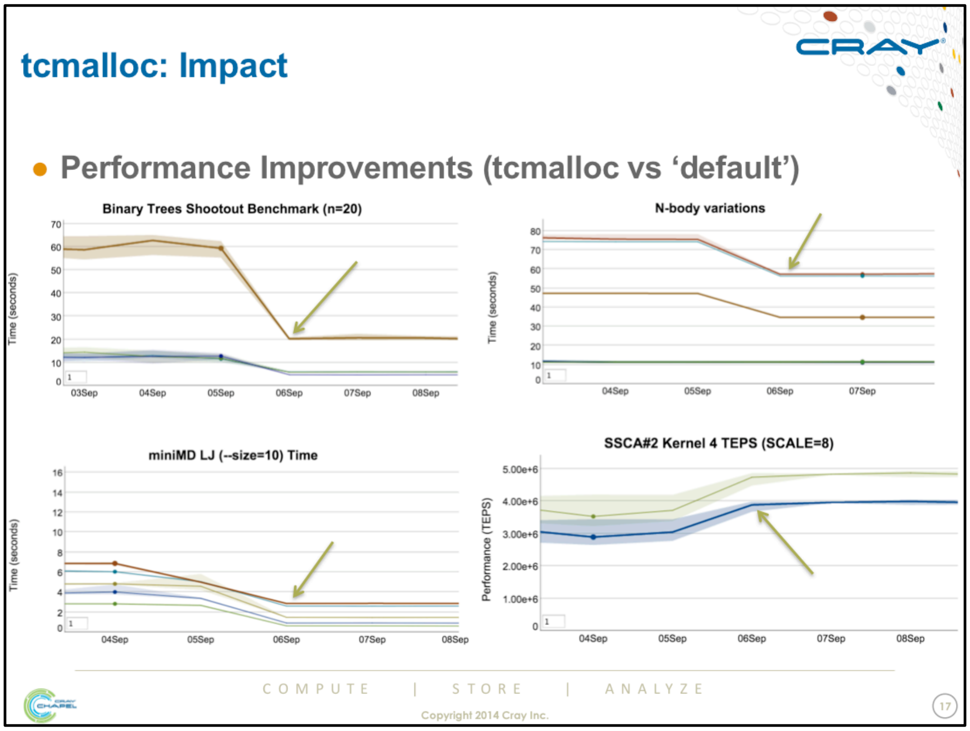
tcmalloc: Background

- **Chapel supports multiple memory allocators**
  - By default we typically use the standard C library malloc/free
  - Other options include tcmalloc and dlmalloc
    - Can be optionally selected by the user
    - tcmalloc is used by default by ugni, dlmalloc by gasnet for fast segment
- **Previous tcmalloc version was from 2011**
  - Outdated, so we were missing bug fixes and performance improvements
  - Newer version contains changes requiring fewer local modifications to work with Chapel



tcmalloc: This Effort

- **Upgrade to v2.2 (May 2014)**
- **Attempt to make tcmalloc the default allocator**
- **Rename ‘default’ to ‘cstdlib’**
  - This was a weak/confusing name to begin with
    - e.g., it wasn’t always the default
  - Once another allocator becomes the default, this name is even worse



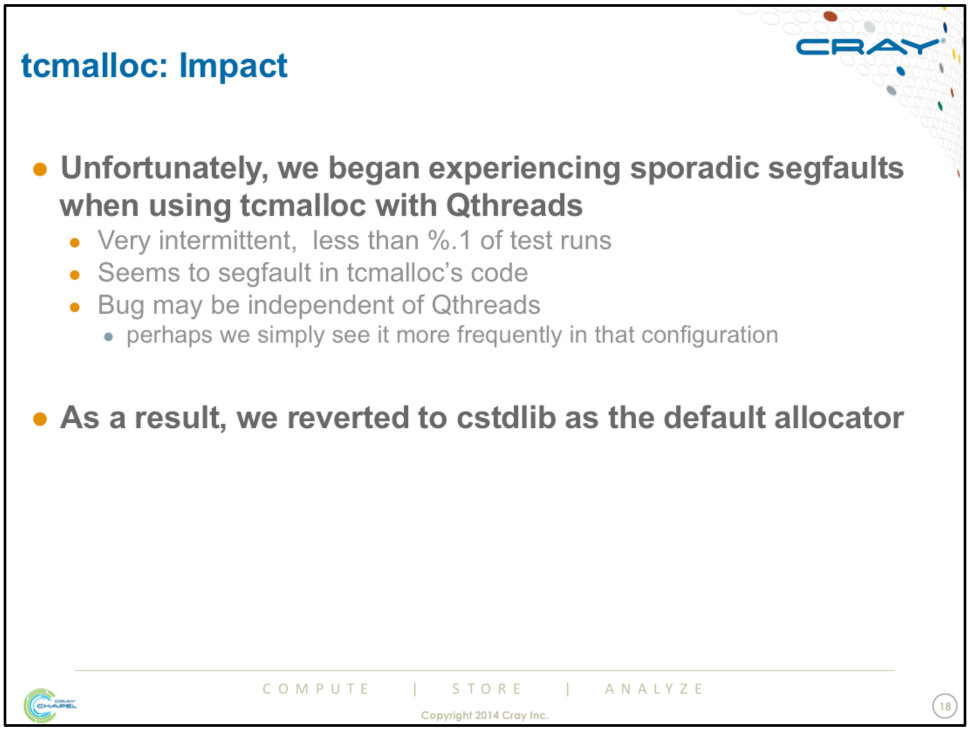
tcmalloc: Impact

- Performance Improvements (tcmalloc vs 'default')

COMPUTE | STORE | ANALYZE

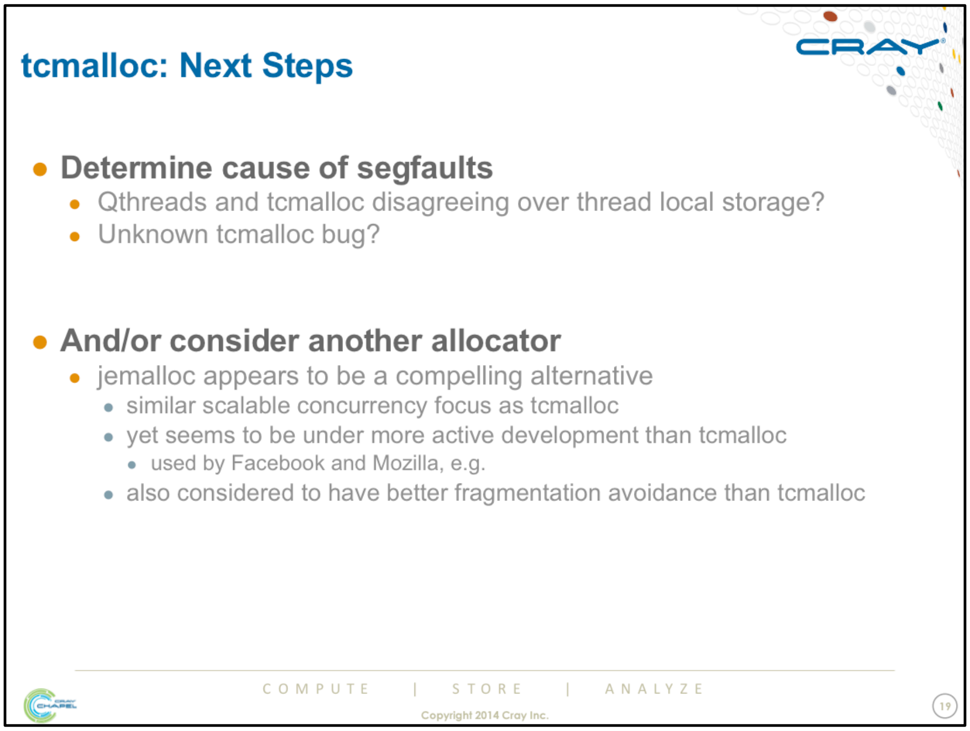
Arrows point to where tcmalloc was made the default

Note that for SSCA#2, higher is better



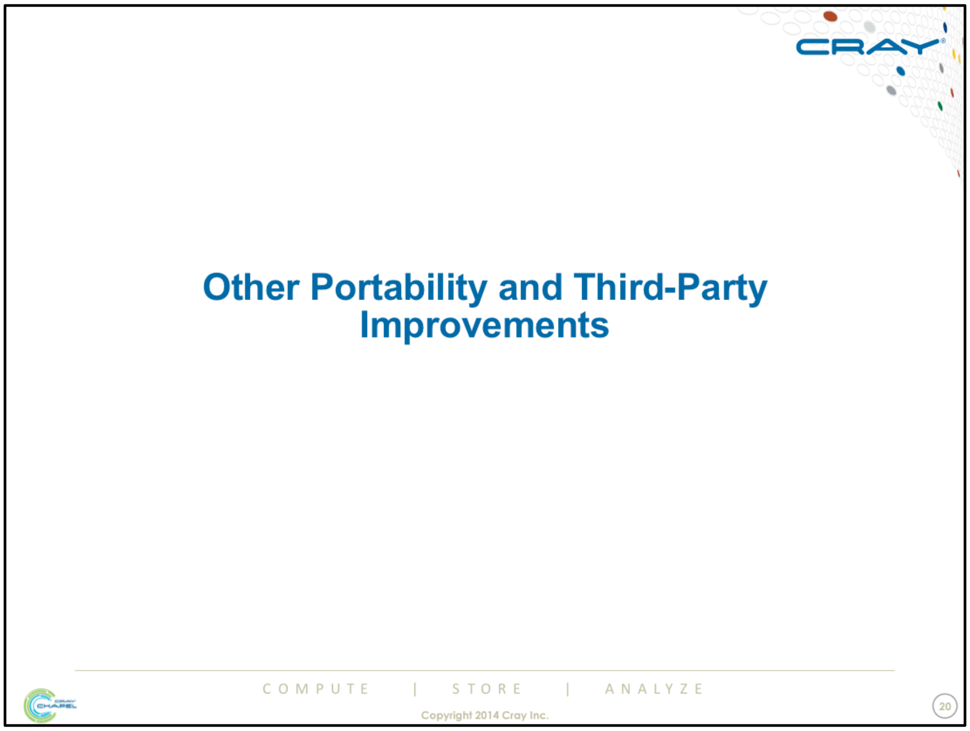
tcmalloc: Impact

- Unfortunately, we began experiencing sporadic segfaults when using tcmalloc with Qthreads
  - Very intermittent, less than %.1 of test runs
  - Seems to segfault in tcmalloc's code
  - Bug may be independent of Qthreads
    - perhaps we simply see it more frequently in that configuration
- As a result, we reverted to cstdlib as the default allocator

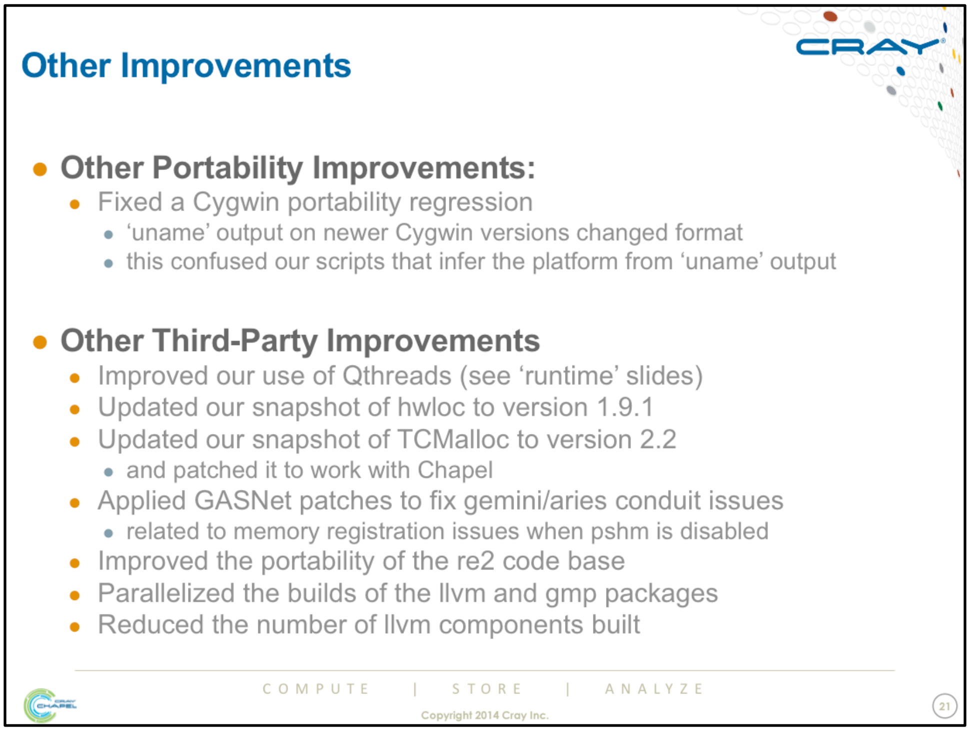


tcmalloc: Next Steps

- Determine cause of segfaults
  - Qthreads and tcmalloc disagreeing over thread local storage?
  - Unknown tcmalloc bug?
- And/or consider another allocator
  - jemalloc appears to be a compelling alternative
    - similar scalable concurrency focus as tcmalloc
    - yet seems to be under more active development than tcmalloc
      - used by Facebook and Mozilla, e.g.
    - also considered to have better fragmentation avoidance than tcmalloc



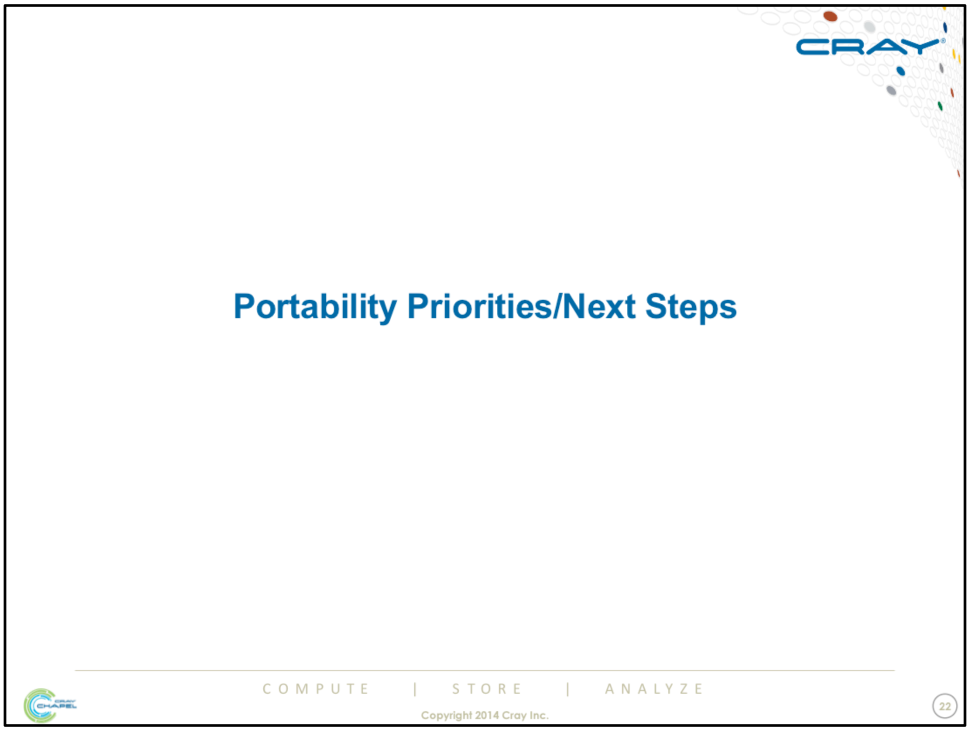
Other Portability and Third-Party Improvements



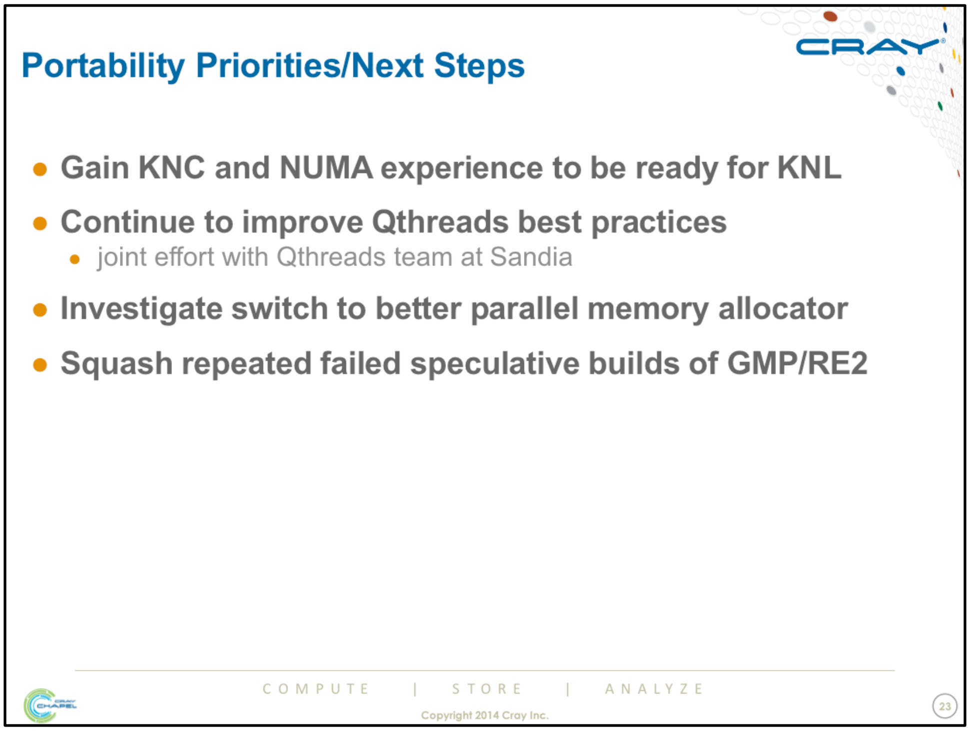
Other Improvements

- **Other Portability Improvements:**
  - Fixed a Cygwin portability regression
    - ‘uname’ output on newer Cygwin versions changed format
    - this confused our scripts that infer the platform from ‘uname’ output

- **Other Third-Party Improvements**
  - Improved our use of Qthreads (see ‘runtime’ slides)
  - Updated our snapshot of hwloc to version 1.9.1
  - Updated our snapshot of TCMalloc to version 2.2
    - and patched it to work with Chapel
  - Applied GASNet patches to fix gemini/aries conduit issues
    - related to memory registration issues when pshm is disabled
  - Improved the portability of the re2 code base
  - Parallelized the builds of the llvm and gmp packages
  - Reduced the number of llvm components built

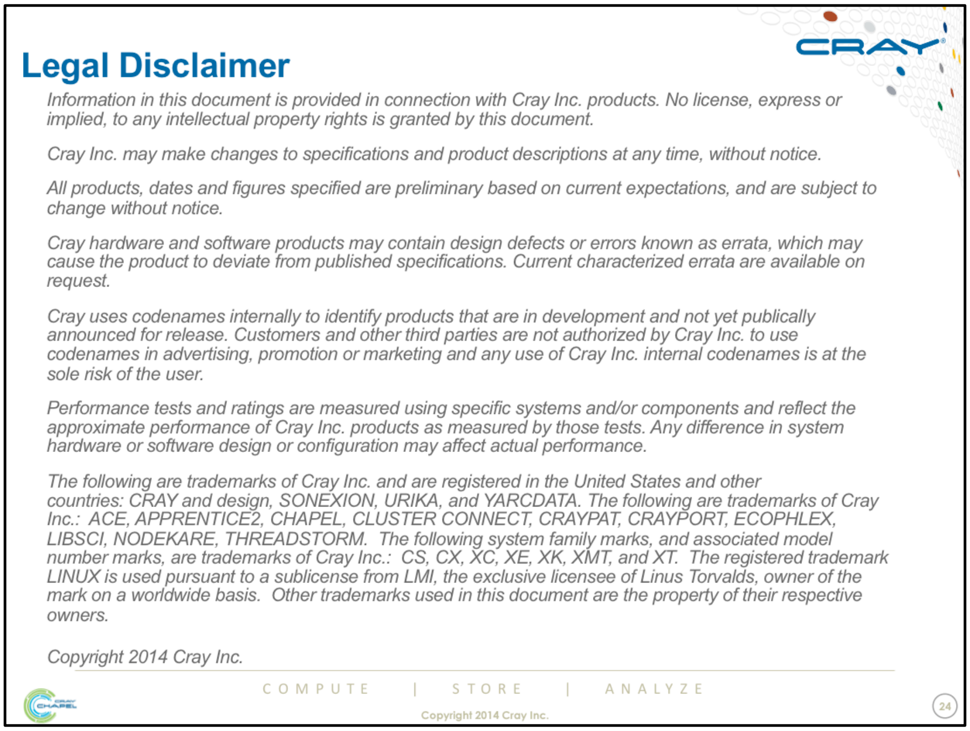


Portability Priorities/Next Steps



Portability Priorities/Next Steps

- Gain KNC and NUMA experience to be ready for KNL
- Continue to improve Qthreads best practices
  - joint effort with Qthreads team at Sandia
- Investigate switch to better parallel memory allocator
- Squash repeated failed speculative builds of GMP/RE2



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