IBM TJ Watson Research Center

HPC Challenge Class 2
UPC and X10 on Multiple Platforms

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Submission Overview

- Two languages:
  - Unified Parallel C (UPC): http://upc.gwu.edu
  - X10: http://x10-lang.org

- One common PGAS runtime to provide performance portability
  - X10 and XLUPC compilers both target the common PGAS runtime
  - Runtime provides services such as threading, data distribution, messaging (including collective communication) thus enabling efficient execution and interoperability

- Two platforms: Power5 SMP clusters and Blue Gene/L
  - Power5 clusters: 32 nodes, 16-way Power5 1.9 GHz, 64 GB memory/node, AIX
  - Blue Gene/L: 8 racks (16K processors) on the BG/W machine

- Four applications (HPL, FFT, Stream, and RandomAccess) coded in both UPC and X10
  - Implementations from scratch using the algorithm specification
  - All applications use SPMD style parallelism in both languages.

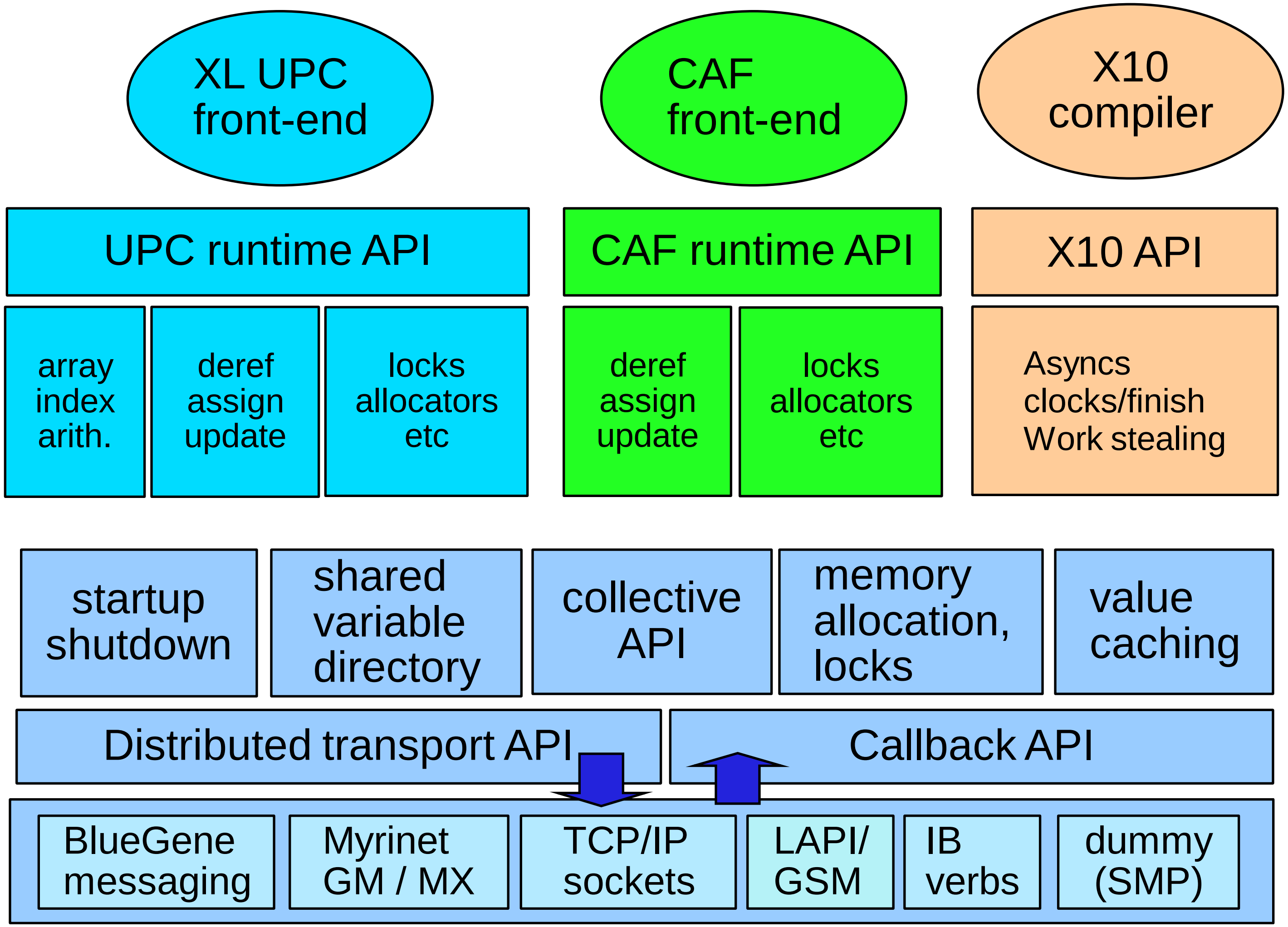
Two teams of programmers, different skills, similar performance

Lines of code

Benchmark	UPC	X10
HPL	600	550(*)
FFT	180	215
Random Access	107	53
STREAM	90	86

*: Reflects code for parallel swaprows

PGAS runtime structure



Productivity Considerations – HPL

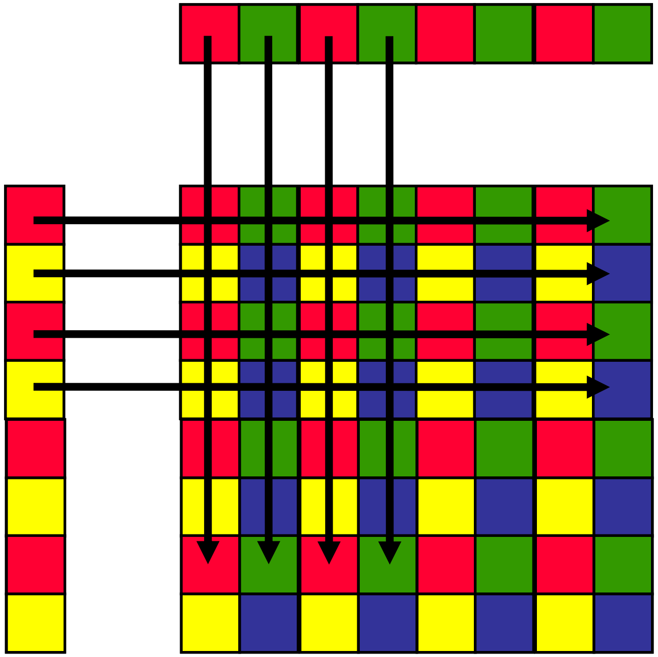
- Both versions, UPC and X10, are implemented using a tiled layout and data-centric communication for scalability
  - Our previous submissions were totally asynchronous and in shared memory (X10) and a naïve global-view (UPC)

- Tiled layout
  - Supported in X10 using a fragmented representation over all places
  - Extended UPC with tiled array expressions and processor layout directives (HPF-like)

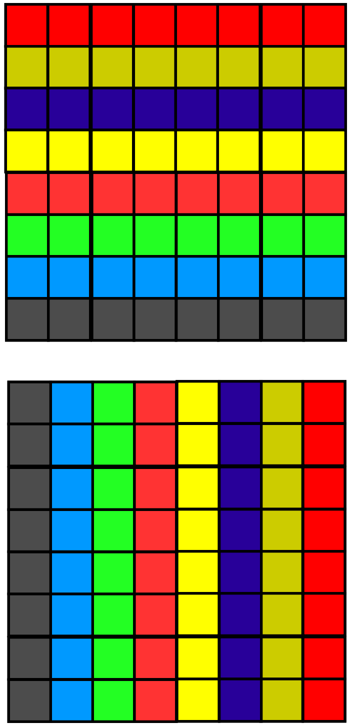
- Data-centric communication: using collectives for communication
  - X10 communicators: dynamic “unique distributions” that provide multi-place broadcast/reduce/barrier a la MPI communicators
  - Teams in UPC that allow collectives on a subset of the threads

- Common runtime support exploited by both language implementations

HPL – Optimized Broadcast



Split communicators:



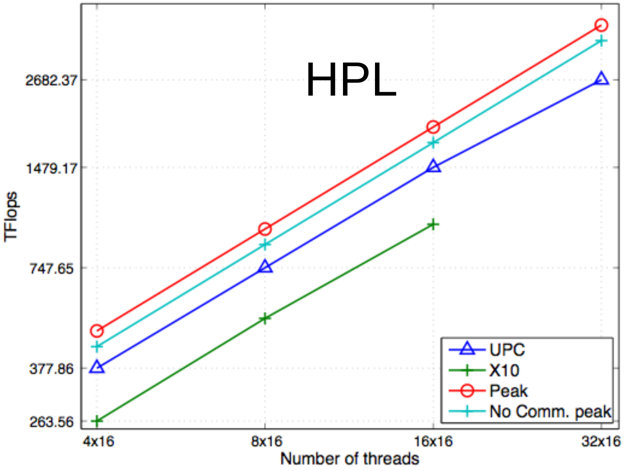
Split by rows

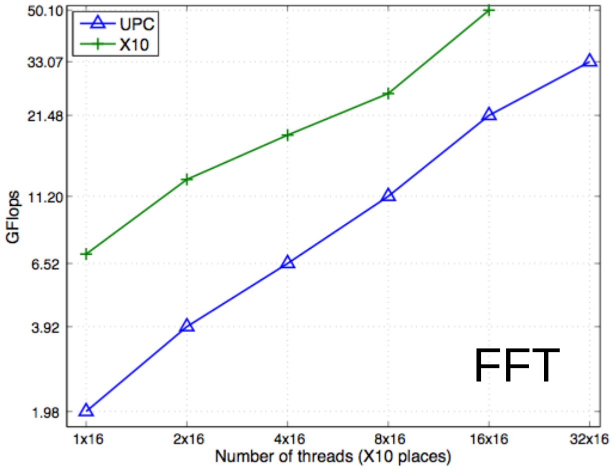
Split by columns

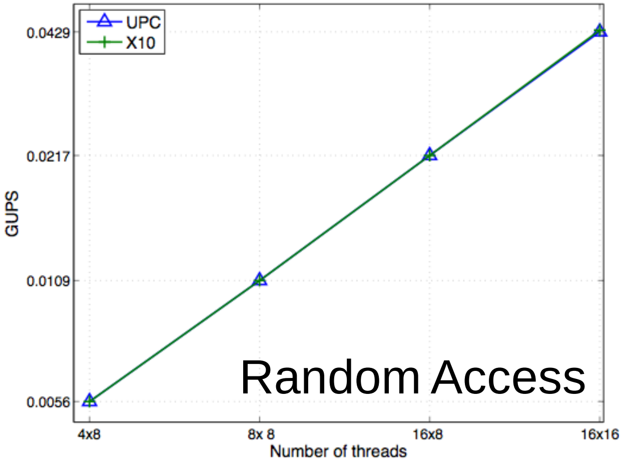
There are TX row-comms and TY col-comms

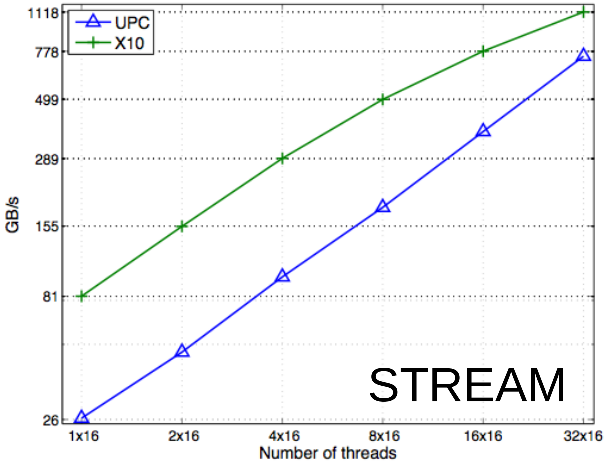
place (i,j) uses the i’th row-comm and the j’th col-comm.

Performance Results: Power5 clusters

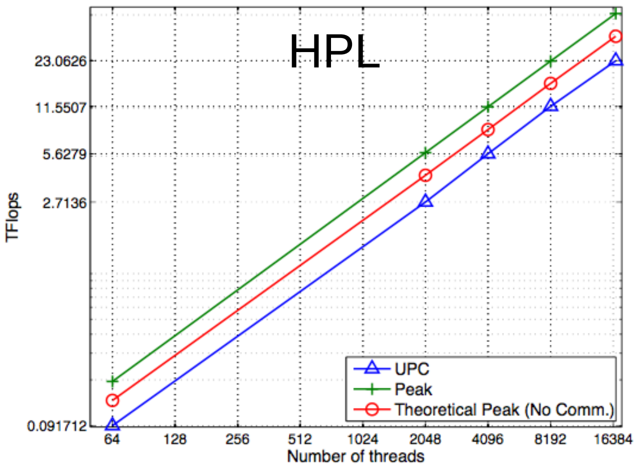


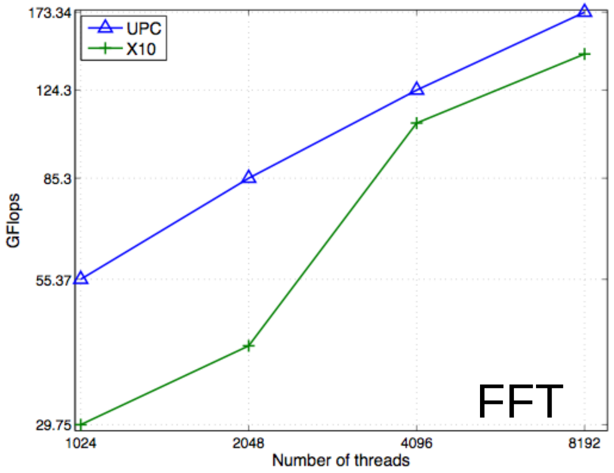


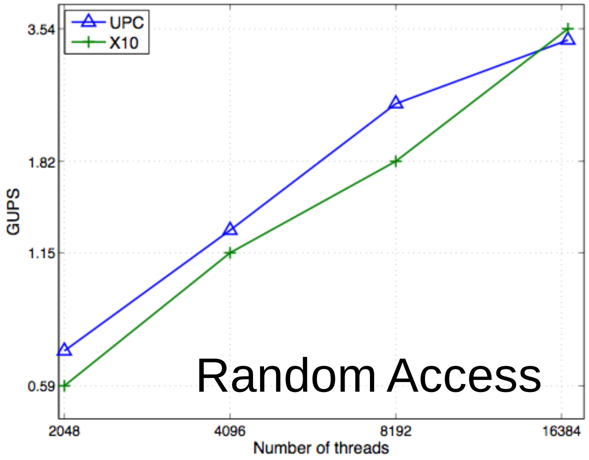


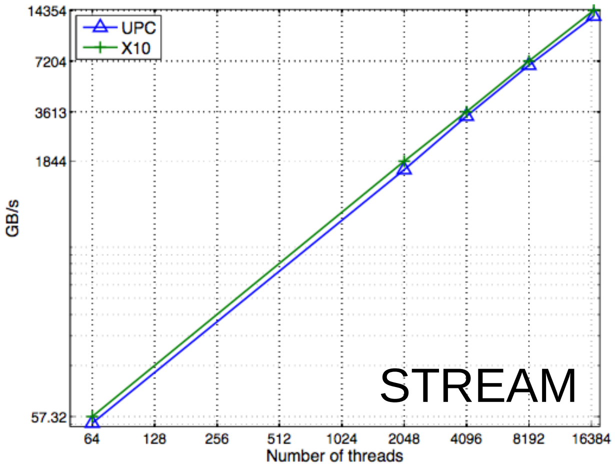


Performance Results: Blue Gene/L









Discussion

- HPL efficiency: Power5 (78% UPC, 55% X10), BG/L (50%)
  - X10: Rank-1 updates used in panel, moving to Rank-K will improve performance
  - X10/BG: Memory leak in generated code affects results on Blue Gene/L
  - UPC+X10: Even higher efficiency expected with better scheduling of updates (cf X10 HCP07 submission)
- Random Access: designed to reach the maximum cross-section bandwidth for largest configurations
  - Blue Gene/L: At 8 racks it reaches 77% efficiency. At 64 racks it reaches 82% efficiency (2006 results)
  - Power5: Each SMP has two adapters, each capable of delivering 1 update/µs through LAPI, performance is limited by the interconnect latency
- FFT: implementation differences
  - X10 implementation is using blocked transposes overlapped with exchange, that pays off for the Power5 cluster, but not on Blue Gene/L
  - UPC is using a naïve non-blocking exchange that better exploits the overall Blue Gene/L cross-section bandwidth
- Stream
  - X10 simpler index computation allows better code generation than UPC on Power5

Why UPC *and* X10?

- Our submission addresses high-productivity, high-performance **programming environment** for programmers
  - An environment is more than a language!
    - Interoperability, performance portability, etc.
  - Lets programmer choose language they are comfortable with (X10 for Java programmers, UPC for C programmers)
- Common runtime helps programmers
  - Easier to write parallel, inter-operating code in both languages
  - Possible to debug programs in one language using a program in the other (e.g. we debugged X10 performance on LU using the UPC program.)
  - Exposes unified abstractions to both languages (e.g. communicators)
    - ➔ These abstractions may serve as a basis for PGAS/MPI interoperability

Additional Information

- X10:

  http://x10-lang.org

- UPC:

  http://domino.research.ibm.com/comm/research_projects.nsf/pages/xlupc.index.html

Thank You!