Berkeley UPC

http://upc.lbl.gov

Overview

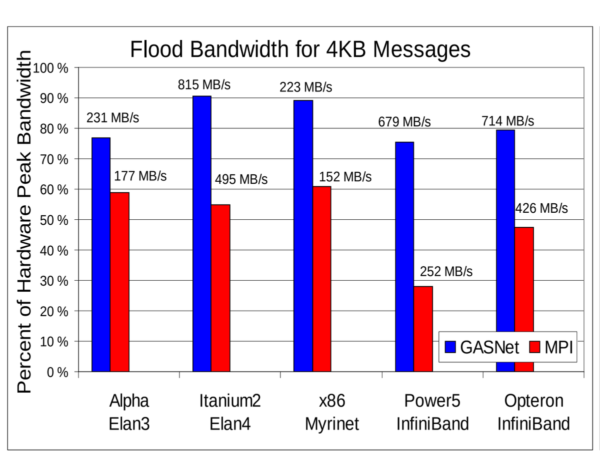
- A portable and high-performance UPC implementation, compliant with UPC 1.2 spec
- Features:
  - High performance UPC Collectives
  - Extensions for performance and programmability
    - Non-blocking memcpy functions
    - Semaphores and signaling put
    - Value-based collectives
    - Atomic memory operations
    - Hierarchical layout query
  - Compiler and runtime optimizations for application scalability
- Open source software (Windows/Mac/UNIX), installation CD available at UPC booth

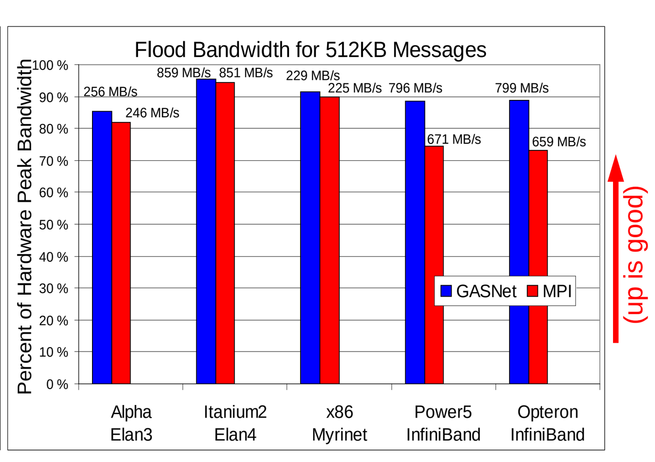
Portable Design

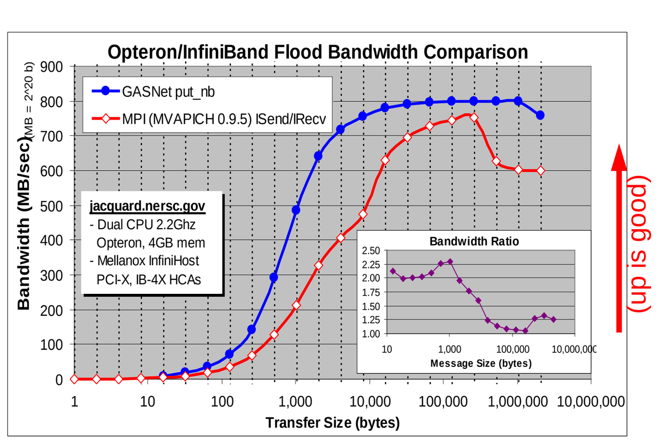
- Layered design, platform-independent code gen
- Supports wide range of SMPs, clusters and MPPs
  - x86, Itanium, Opteron, Athlon, Alpha, PowerPC, MIPS, PA-RISC, SPARC, T3E, X1, SX-6, XT3, Blue Gene, …
  - Linux, FreeBSD, NetBSD, Tru64, AIX, IRIX, HPUX, Solaris, MS Windows, Mac OS X, Unicos, SuperUX, …
  - Pthreads, Unix SysV, Myrinet, Quadrics Elan 3/4, Infiniband, IBM LAPI, Dolphin SCI, MPI, Ethernet, Cray X1 / SGI Altix shmem, Cray XT3 Portals

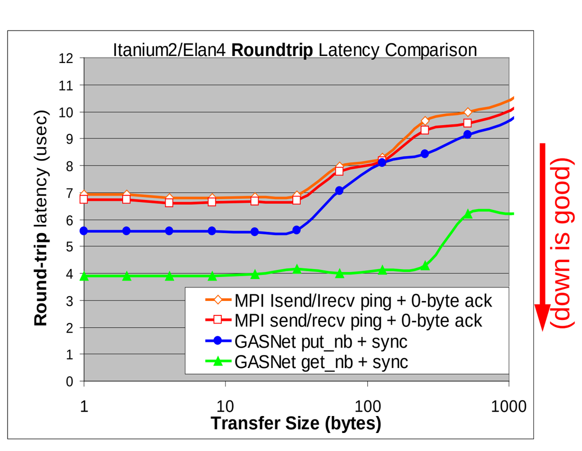
BUPC Runtime + GASNet

- Well-documented runtime interface, multiple UPC compilers (Berkeley UPC and Intrepid GCC/UPC)
- Debugging and tracing support
  - Performance Instrumentation Support (GASP)
  - Supports Parallel Performance Wizard (PPW)
  - Detailed communication tracing support
  - Etnus TotalView debugger support
- Interoperability with other programming env:
  - UPC calls to/from C, C++, Fortran, MPI
- Berkeley GASNet used for communication:
  - Performance from inline functions, macros, and network-specific implementations
- Optimized Collective ops (booth poster)
- High-performance communication
  - Consistently matches or outperforms MPI
  - One-sided, lightweight semantics







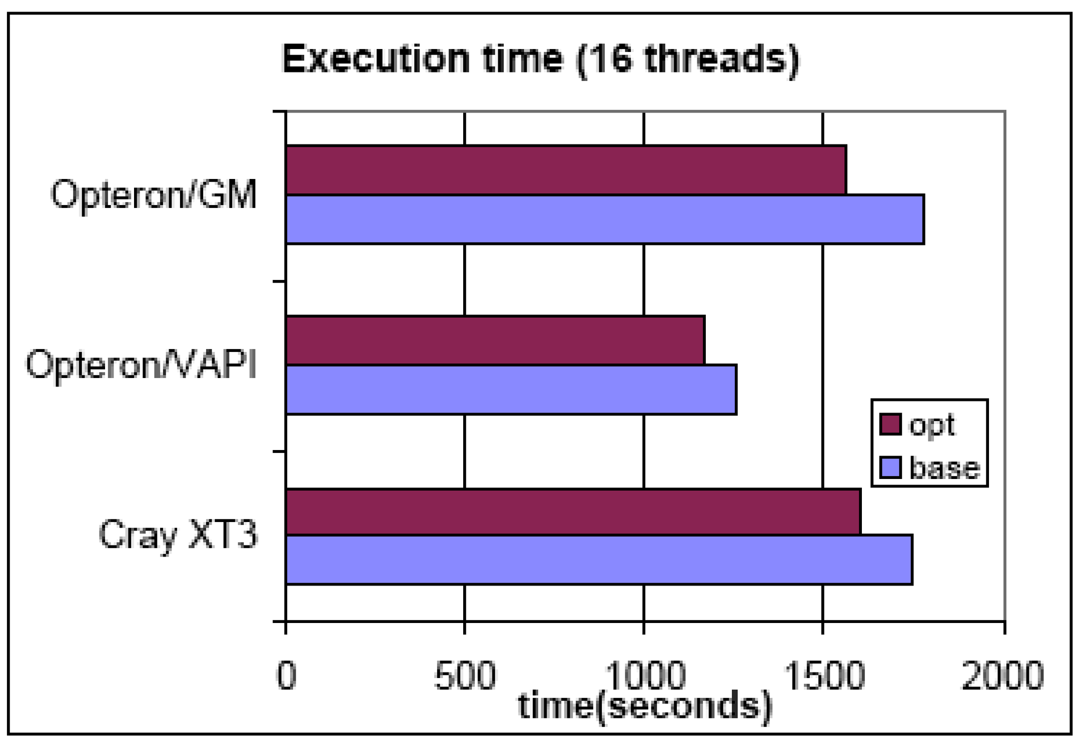


UPC-to-C Translator

- Source-to-source translator, based on Open64
- Platform for experimenting with one-sided communication optimizations, as well as UPC specific optimizations: compiler, runtime, communication libraries

Fine Grained Programming Optimizations

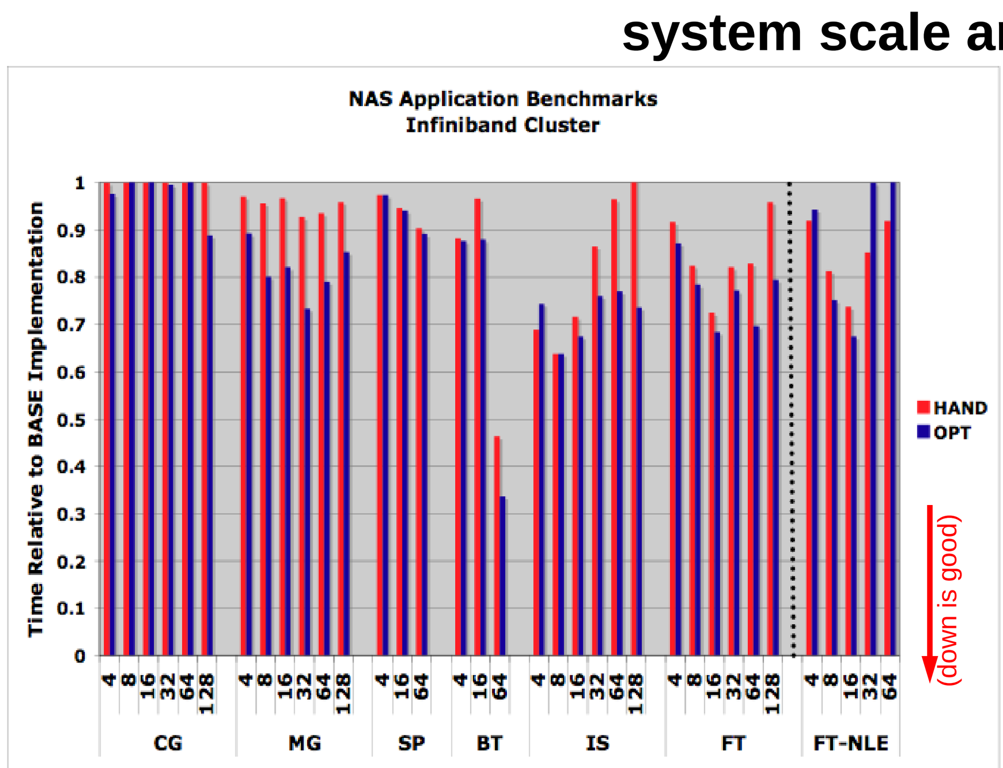
- Partial-Redundancy Elim. on shared ptrs
  - pointer add, load, and store
- Split-phase comm. – moves read initiations up, write completions down
- Coalesce fine-grained accesses to same struct/array



Impact of optimization on CFD code developed at the Army High Performance Computing Research Center. (Hummingbird CFD simulation courtesy of A. Johnson)

Coarse Grained Programming Optimizations

- Compile time message vectorization and strip-mining
- Runtime Analysis: communication instantiated at runtime based on system specific performance models
- Performance models designed to take system scale and load into account



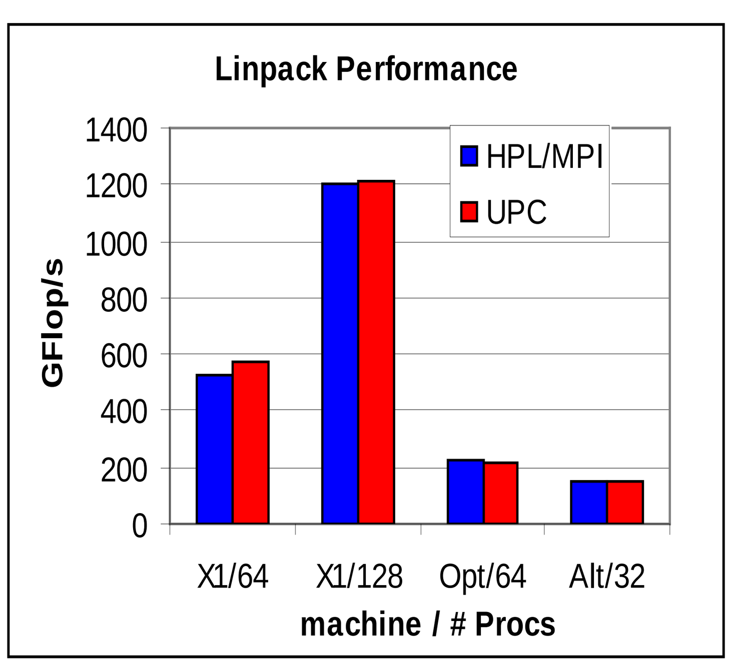
Communication dynamically instantiated using either Put/Get or VIS calls

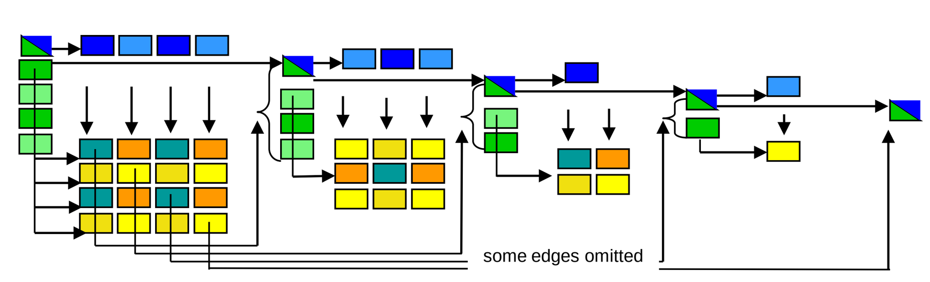
Overall improved application scalability and programmer productivity

Multithreading for Latency Hiding

When memory is distributed one needs
- Locality and Load Balance
- Remote synchronization for dependencies
- Latency Tolerance

Case Study - Linpack
- 2d block cyclic decomposition as in ScaLAPACK
- Cooperative multi-threading to mask dependences
- Non-blocking (remote get) transfers to mask latency
- Memory-constrained lookahead compared to none in ScaLAPACK, fixed parameter in MPI/HPL
- Application-level scheduling to prioritize critical path





Other results:
Itanium 2/Elan 4.1 – 2.25 TFlop/s, 78.5% of peak on 512p
1p Itanium 2 1.5 GHz – 91.8% of peak
1p Opteron 2.2GHz – 81.9% of peak