Improving Performance of All-to-All Communication Through Loop Scheduling in PGAS Environments

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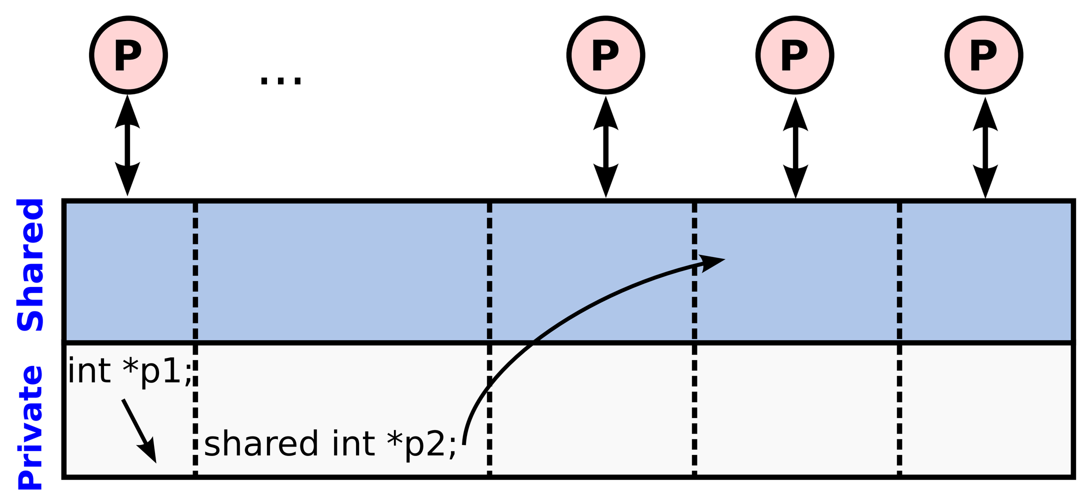
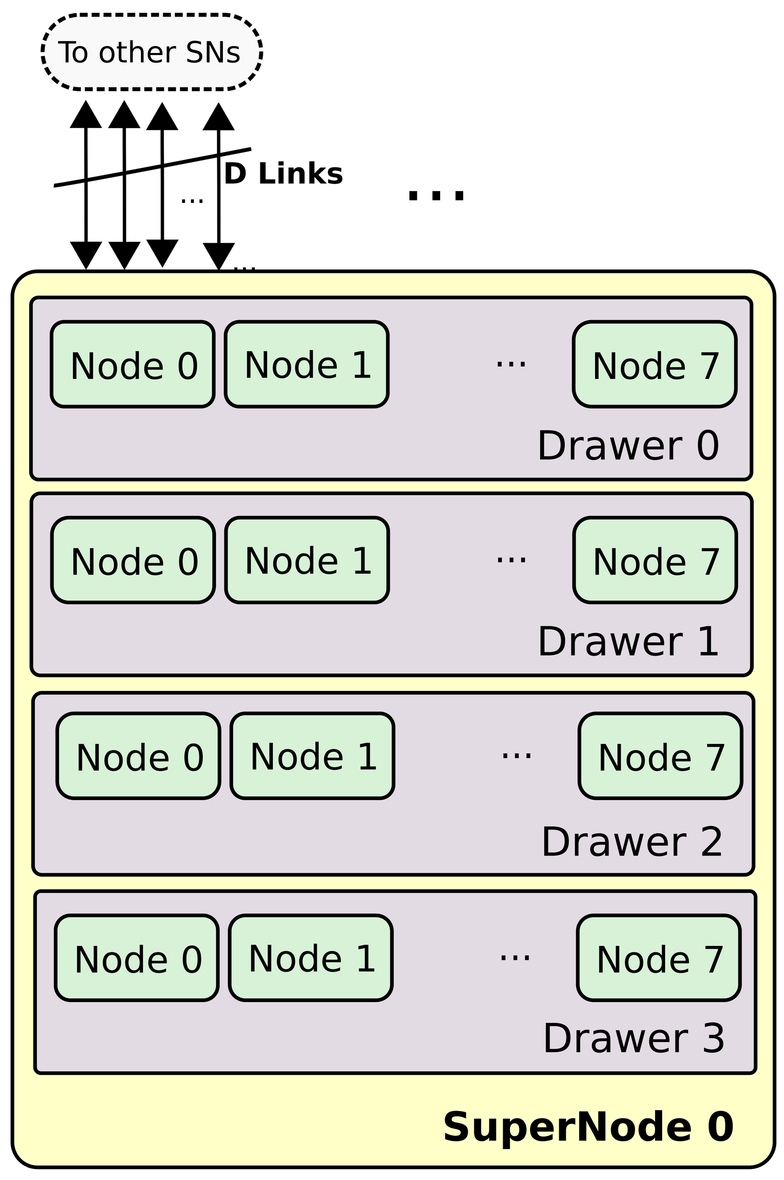
Partitioned Global Address Space (PGAS)

- Goal: Simplicity of shared-memory...
- ...with efficiency of the message-passing paradigm
- Shared or distributed memory
- Unified Parallel C (UPC): ISO C 99 extension



Motivation

- All-to-all communication suffer from node oversubscription
- Manual or compiler code optimization is required



We propose

- Loop scheduling for better network utilization

Platform

- XL UPC framework
- Power775: 32 Nodes x 32 Cores
- Hub-Chip: High-Radix topology

Loop Scheduling

- Core idea: schedule the accesses to ensure that each thread will not access the same shared data
- Spread communication across all the nodes
  - Avoid node over subscription
  - Avoid network hotspots

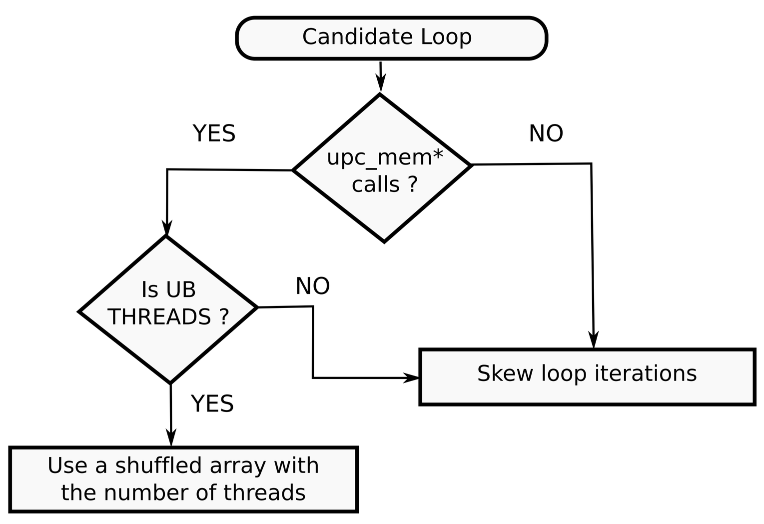
Loop Transformation Approaches

- Skew loops and start from a different point
  - NEW_IV = (IV +MYTHREAD×Block) % LOOP_UB;

  Where $Block = \frac{SIZE\_OF\_ARRAY}{THREADS}$
- Strided accesses: starting from a different Node
  - NEW_IV = Block×(IV ×33+MYTHREAD) % LOOP_UB;
- Random shuffled: when the upper bound is the number of threads

Compiler loop transformation

- The compiler categorizes the loops in two categories based on the loop upper bound and type of accesses
- The compielr inserts the new code and replaces any occurance of the induction variable



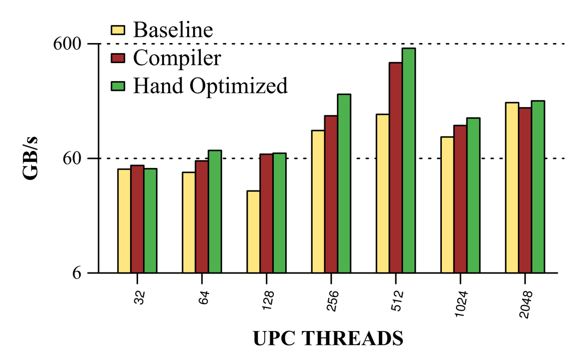
Example Transformed Code:

```
shared [N/THREADS] double X[N];
shared [N/THREADS] double Y[N];

// Example All-to-all
void memget_threads_rand(){
   uint64_t i=0, block = N/THREADS;
   double *lptr = (double *) &X[block*MYTHREAD];
   uint64_t *tshuffle = __random_thread_array();

   for (i=0;i<THREADS;i++){
      uint64_t idx = tshuffle[i];
      upc_memget( lptr, &Y[idx*block],
                  block*sizeof(double));
   }
}
```

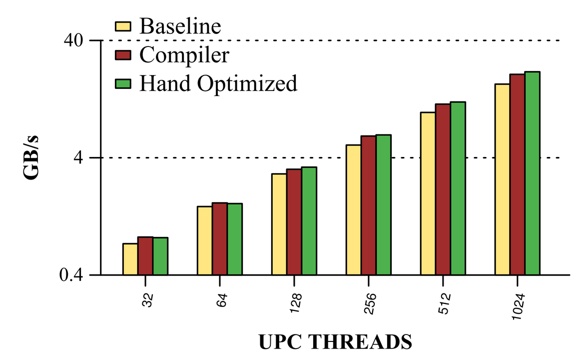
Current state & ongoing research

- Demonstrated performance improvements using several applications, further tuning underway
- Microbenchmarks: slightly lower performance that the manual optimized benchmark
- NAS FT achieves a speedup between 3% up to 15% due to all-to-all transpose
- Bucket-sort achieves 3-8% performance grain except when running with 32 UPC threads
- The optimization is effective and scales well, when the communication takes a considerate amount of time
- Current research aims to 1) decrease the overhead of compiler 2) Find more optimal traffic scheduling 3) Cover more cases

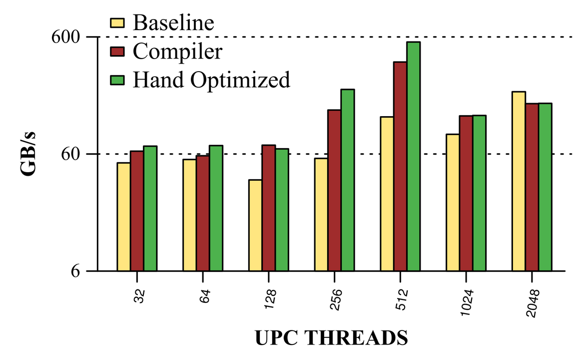
UPC Memput



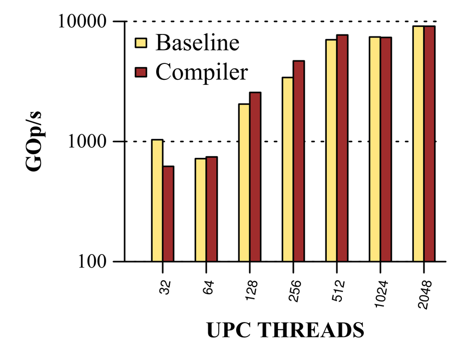
Fine grained get



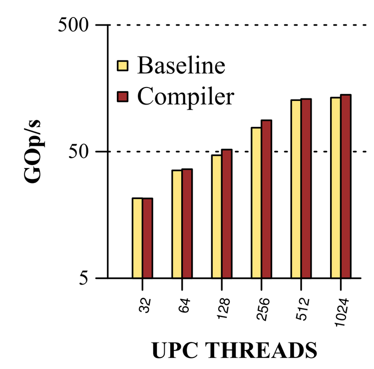
UPC Memget



Bucketsort



FT



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