Implementation and Performance of NPB

In order to investigate the performance of parallel programs written in XcalableMP, we have implemented NAS Parallel Benchmarks, the Integer Sort (IS) benchmark and the Conjugate Gradient (CG) benchmark.

Integer Sort

The IS benchmark tests a sorting operation that is important in particle method codes. IS is based on the “bucket sort” algorithm to sort large arrays of integers.

```
#pragma xmp coarray key_buff2
…
#pragma xmp loop on t(i)
for(i=0; i<NUM_KEYS; i++)
  bucket_size[key_array[i] >> shift]++;
…
for(i=0;i<NUM_PROCS;i++)
  key_buff2[a[i]:b[i]]:[i] = key_buff1[c[i]:d[i]];
```

First line is to declare coarray for local view programming. Next “loop” directive and “for statement” are to create a histogram which is used by the sort. The array key_array[] is a distributed array. Last “for statement” is to exchange the keys at each node with using coarray. Array a[], b[], c[] and d[] are information of send points and receive points of each node.

Conjugate Gradient

In the CG benchmark, the conjugate gradient method is used to compute an approximation to the smallest eigenvalue of a large, sparse, symmetric positive definite matrix.

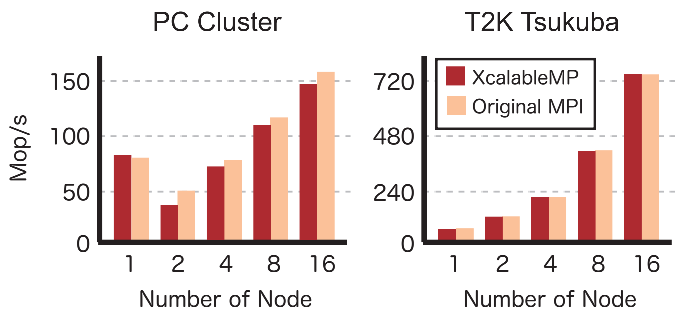
```
#pragma xmp distribute(block,block) on pros
…
#pragma xmp loop on t(*,j)
for (j=1; j<=lastrow-firstrow+1; j++) {
  sum = 0.0;
  for (k=rowstr[j]; k<rowstr[j+1]; k++) {
    sum = sum + a[k]*p[colidx[k]];
  }
  w[j] = sum;
}
#pragma xmp reduction(+:w) on p(*,:)

#pragma xmp gmove
q[:] = w[:];
```

Two-dimensional template is declared in first line and one-dimensional working arrays(p[], q[], w[]) are aligned to one dimension of the template. Index arrays(rowstr[], colidx[]) are calculated to refer the array a[] before entering the loop in each node. This operation enables the nested loop statements to be calculated which causes an equivalent processing with the MPI version of CG. The “gmove” directive copies all elements of array w[] to array q[] with different distributions.

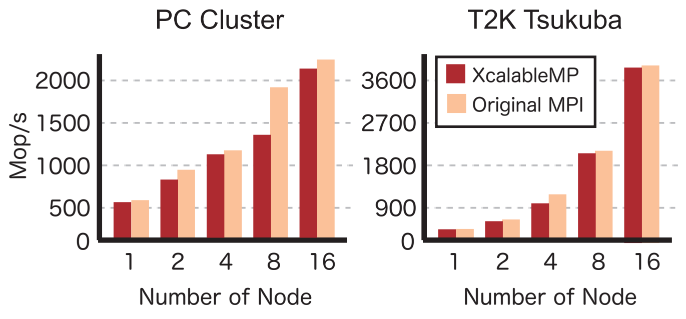
Performance Results

	PC Cluster	T2K Tsukuba
CPU	Intel Core2 Quad CPU Q9650 3.0GHz	AMD Opteron Quad Core 8000 series 2.3GHz
Network	Gigabit Ethernet	Infiniband DDR (4 rails)

Integer Sort



Conjugate Gradient



The results indicate that the performance of XcalableMP is comparable to that of MPI.

Reference

[1] Jinpil Lee and Mitsuhisa Sato, “Implementation and Perfor-mance Evaluation of XcalableMP“, A Parallel Programming Language for Distributed Memory Systems, 39th Annual International Conference on Parallel Processing (2010)

[2] Masahiro Nakao, Jinpil Lee, Taisuke Boku and Mitsuhisa Sato. “XcalableMP Implementation and Performance of NAS Parallel Benchmarks”, Fourth Conference on Partitioned Global Address Space Programming Model (PGAS10), NewYork, USA, Oct. (2010)