CSCI596 Assignment 3—Parallel Computation of π and Scalability Analysis —Answer

Part I: Program—global_pi.c

```
#include "mpi.h"
#include <stdio.h>
#define NBIN 1000000000  /* Number of quadrature points */
int nprocs;              /* Number of processes */
int myid;                /* My rank */

double global_sum(double partial) {
  MPI_Status status;
  int bitvalue, partner;
  double mydone, hisdone;

  mydone = partial;
  for (bitvalue=1; bitvalue<nprocs; bitvalue *= 2) {
    partner = myid ^ bitvalue;  /* XOR flips the l-th bit */
    MPI_Send(&mydone, 1, MPI_DOUBLE, partner, bitvalue, MPI_COMM_WORLD);
    MPI_Recv(&hisdone, 1, MPI_DOUBLE, partner, bitvalue, MPI_COMM_WORLD, &status);
    mydone += hisdone;
  }
  return mydone;
}

int main(int argc, char *argv[]) {
  long long i;
  double step, x, sum = 0.0, partial, pi, cpu1, cpu2;
  step = 1.0/NBIN;

  MPI_Init(&argc, &argv);
  MPI_Comm_rank(MPI_COMM_WORLD, &myid);
  MPI_Comm_size(MPI_COMM_WORLD, &nprocs);

  cpu1 = MPI_Wtime();
  for (i=myid; i<NBIN; i+=nprocs) {
    x = (i+0.5)*step;
    sum += 4.0/(1.0+x*x);
  }
  partial = sum*step;

  pi = global_sum(partial);
  cpu2 = MPI_Wtime();

  if (myid == 0) {
    printf("Nprocs & Global sum = %d %le\n", nprocs, pi);
    printf("Execution time (s) = %le\n",cpu2-cpu1);
  }

  MPI_Finalize();
  return 0;
}
```

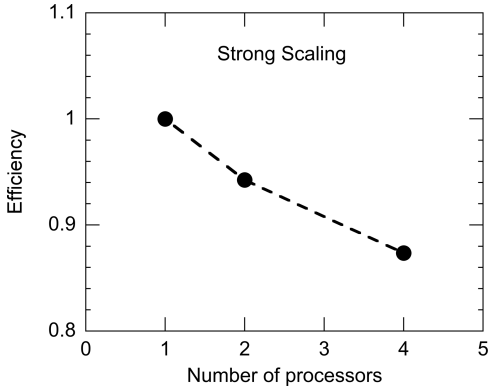
The above program is for the strong-scaling test. For the weak-scaling test, make the following changes, and name the resulting program as `global_pi_iso.c`:

```
#define NPERP 1000000000  /* Number of quadrature points per processor */
...
long long NBIN;
NBIN = (long long)NPERP*nprocs;
```

Part II: Scalability

Fixed Problem-Size (Strong) Scaling

The figure below shows the fixed problem-size (*i.e.* strong-scaling) parallel efficiency as a function of the number of processors on the Discovery cluster, where the number of quadrature points is fixed as 10^9.



Isogranular (Weak) Scaling

The figure below shows the isogranular (*i.e.* weak-scaling) parallel efficiency as a function of the number of processors on the Discovery cluster, where the number of quadrature points per processor is 10^9. We observe that the parallel efficiency is higher for weak scaling than that for strong scaling.