CS 596: Introduction to Parallel Computing
Homework 2:
MPI Programming [Draft]

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\[ \pi = \frac{\text{Circumference of a Circle}}{\text{Diameter of a Circle}} \]

Image Source: http://www.mathsisfun.com/numbers/pi.html
Homework #1, Problem #1: Using Numerical Integration to Estimate $\pi$

- Integral representation for $\pi$
  \[ \int_0^1 dx \frac{4}{1+x^2} = \pi \]

- Discretize the problem:
  \[ \Delta = \frac{1}{N} : \text{step} = \frac{1}{N_{\text{areas}}} \]
  \[ x_i = (i + 0.5)\Delta (i = 0, \ldots, N_{\text{areas}} - 1) \]
  \[ \sum_{i=0}^{N-1} \frac{4}{1+x_i^2} \Delta \approx \pi \]

$\pi$ Formulae: http://en.wikipedia.org/wiki/Approximations_of_pi
Image: http://cacs.usc.edu/education/cs596/mpi-pi.pdf
Homework #1, Problem #1: Using Numerical Integration to Estimate $\pi$

```c
#include <stdio.h>
#define NAREA 10000000
void main() {
    int i; double step,x,sum=0.0,pi;
    step = 1.0/NAREA;
    for (i=0; i<NAREA; i++) {
        x = (i+0.5)*step;
        sum += 4.0/(1.0+x*x);
    }
    pi = sum*step;
    printf(PI = %f\n,pi);
}
```
HW #1, Problem #1: Using Numerical Integration to Estimate $\pi$

- Use the method of numerical integration to estimate the value for $\pi$
- Note: the Numerical Integration is used to solve any function $f(x)$
- Design and write a parallel version to estimate $\pi$ using the formula above or another approach. Explain how your formula works.
  - See the Trap example discussed in Pachecho 2011, Ch 3.
  - You can use point-to-point or collective communications.
  - You must run jobs on the queue.
  - Vary the number of areas used: $N_{\text{areas}} = 10^n$, where $n = 1, 2, 3$,
  - Vary the number of PEs: $np = [1, 2, 4, 8, 16]$
  - Time the job runs.
Homework #2, Problem #1: Using Numerical Integration to Estimate π

What to Report/Turn in:

- Estimate π to the limits of a double precision number on the student cluster
- Calculate the value for π and the error of your estimate as a function of the number or areas used
- Calculate the value for π and the error of your estimate as a function of the number or areas used
- Relevant tables of your test data
- Plot the error as a function of the number of processors and number of points.
- Plot the runtime as a function of the number of processors and number of points.
- A copy of your code (single spaced, two column format is OK).
- Reference key sources of information (Pacheco, lectures, Web, ).
Sieve of Eratosthenes: Basic Algorithm

- A prime number is a natural number which has exactly two distinct natural number divisors: 1 and itself.
- To find all the prime numbers less than or equal to a given integer n by Eratosthenes’ method:
  - Create list of consecutive integers from 2 through n: (2, 3, 4, ..., n).
  - Initially, let p equal 2, the first prime number.
  - Starting from p, enumerate its multiples by counting to n in increments of p, and mark them in the list (these will be 2p, 3p, 4p, etc.; the p itself should not be marked).
  - Find the first number greater than p in the list that is not marked. If there was no such number, stop. Otherwise, let p now equal this new number (which is the next prime), and repeat from step 3.
  - When the algorithm terminates, all the numbers in the list that are not marked are prime.
Due: 10/14/14

Calculate the number of prime numbers that exist within a defined range

Use the Sieve of Eratosthenes approach:

- Consider different data distributions – try cyclic distribution.
- You can use point-to-point or collective communications.
- You must run jobs on the queue.
- Vary the value for: $N_{\text{areas}} = 10^n$, where $n = 1, 2, 3$,
- Determine $N_{\text{max}}$ that can be run on tuckoo.
- Vary the number of PEs: $np = [1, 2, 4, 8, 16]$
- Time the job runs
What to Report/Turn in:

- Explain the value you obtained for $N_{\text{max}}$ and why it occurred.
- Plot the runtime as a function of the number of processors and number of primes.
- A copy of your code (single spaced, two column format is OK).
- Reference key sources of information (Pacheco, lectures, Web, ).