Homework 4
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Modifications:

The loop "for(i=0;i<xgft_h;i++)" at line 295 of the original file was made parallel using OpenMP.

The following variables were moved inside the loop to implicitly make them private variables of the parallized loop.

```
    int d;
    int flow_per_node;
    double used_BW;
    long long int ptr,ptr2;
```

The min_rate_limit variable was made into a reduction variable…

```
#pragma omp parallel for reduction(min:min_rate_limit)
    for(i=0;i<xgft_h;i++){
```

Results:
The test was conducted on my home PC.
OS: Ubuntu 18.04 LTS (64 bit)
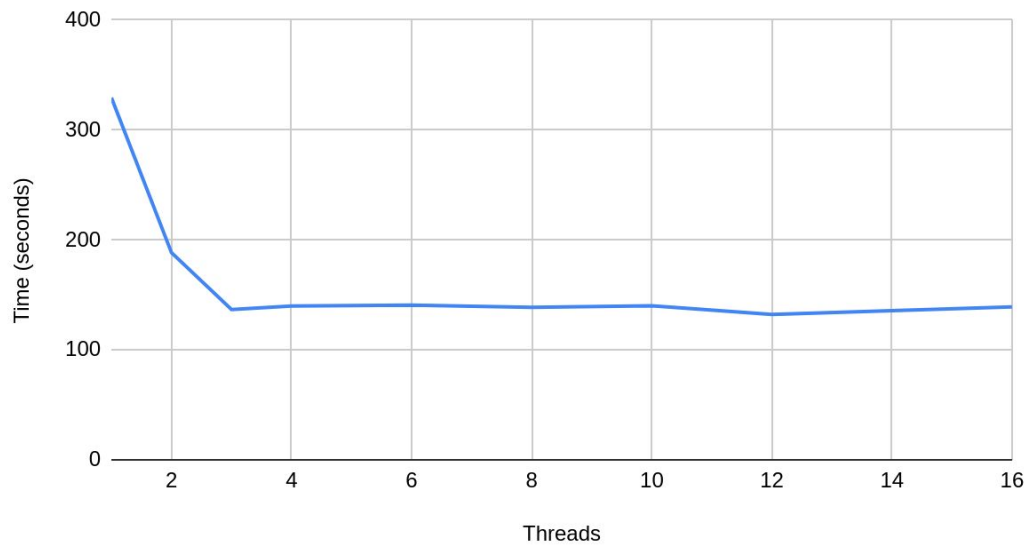Processor: Intel 8700K (6 cores / 12 threads)
Compiler: GCC 7.5.0 (OpenMP 4.5)

Benchmark (single threaded time): 323.1 seconds
Best time: at 12 threads 132.3 seconds.
In all tests the resulting *Average per-flow MMF rate* was 0.049475

Time vs. Threads

Threads	Time
1	329.4
2	188.4
3	136.7
4	139.9
6	140.7
8	138.62
10	140.1
12	132.3
16	139.1

Raw output from the test

john@Poseidon-Ubuntu:~/repos/CSI4360/Homework4/mmf$ ./test.sh
export OMP_NUM_THREADS=16
Simulating XGFT with parameters: height = 3
  m = [18, 18, 36]
  w = [1, 18, 18]
  bw = [1, 1, 1]
sizeL[0] = 11664
sizeL[1] = 648
sizeL[2] = 648

sizeL[3] = 324
baseL[0] = 0
baseL[1] = 11664
baseL[2] = 12312
baseL[3] = 12960
11664 PEs, 1620 switches, 13284 nodes (switch+PE)
Routing algorithm: KPATH
Time to initialize: 2.235912
Time to read from input: 0.048294
Paths processed during input 233264
Time to run iterative algo: 136.864199, #iterations = 12065
Time to calculate final mmf_bw: 0.044588
total elapsed time at MMF: 139.192993
Average per-flow MMF rate is 0.049475
export OMP_NUM_THREADS=12
Simulating XGFT with parameters: height = 3
  m = [18, 18, 36]
  w = [1, 18, 18]
  bw = [1, 1, 1]
sizeL[0] = 11664
sizeL[1] = 648
sizeL[2] = 648
sizeL[3] = 324
baseL[0] = 0
baseL[1] = 11664
baseL[2] = 12312
baseL[3] = 12960
11664 PEs, 1620 switches, 13284 nodes (switch+PE)
Routing algorithm: KPATH
Time to initialize: 2.206291
Time to read from input: 0.044662
Paths processed during input 233264
Time to run iterative algo: 130.076310, #iterations = 12065
Time to calculate final mmf_bw: 0.045889
total elapsed time at MMF: 132.373152
Average per-flow MMF rate is 0.049475
export OMP_NUM_THREADS=10
Simulating XGFT with parameters: height = 3
  m = [18, 18, 36]
  w = [1, 18, 18]
  bw = [1, 1, 1]
sizeL[0] = 11664
sizeL[1] = 648

sizeL[2] = 648
sizeL[3] = 324
baseL[0] = 0
baseL[1] = 11664
baseL[2] = 12312
baseL[3] = 12960
11664 PEs, 1620 switches, 13284 nodes (switch+PE)
Routing algorithm: KPATH
Time to initialize: 2.219700
Time to read from input: 0.044466
Paths processed during input 233264
Time to run iterative algo: 137.845839, #iterations = 12065
Time to calculate final mmf_bw: 0.045316
total elapsed time at MMF: 140.155321
Average per-flow MMF rate is 0.049475
export OMP_NUM_THREADS=8
Simulating XGFT with parameters: height = 3
  m = [18, 18, 36]
  w = [1, 18, 18]
  bw = [1, 1, 1]
sizeL[0] = 11664
sizeL[1] = 648
sizeL[2] = 648
sizeL[3] = 324
baseL[0] = 0
baseL[1] = 11664
baseL[2] = 12312
baseL[3] = 12960
11664 PEs, 1620 switches, 13284 nodes (switch+PE)
Routing algorithm: KPATH
Time to initialize: 2.233468
Time to read from input: 0.044625
Paths processed during input 233264
Time to run iterative algo: 136.303772, #iterations = 12065
Time to calculate final mmf_bw: 0.043724
total elapsed time at MMF: 138.625589
Average per-flow MMF rate is 0.049475
export OMP_NUM_THREADS=6
Simulating XGFT with parameters: height = 3
  m = [18, 18, 36]
  w = [1, 18, 18]
  bw = [1, 1, 1]
sizeL[0] = 11664

sizeL[1] = 648
sizeL[2] = 648
sizeL[3] = 324
baseL[0] = 0
baseL[1] = 11664
baseL[2] = 12312
baseL[3] = 12960
11664 PEs, 1620 switches, 13284 nodes (switch+PE)
Routing algorithm: KPATH
Time to initialize: 2.206850
Time to read from input: 0.044681
Paths processed during input 233264
Time to run iterative algo: 138.378189, #iterations = 12065
Time to calculate final mmf_bw: 0.045041
total elapsed time at MMF: 140.674761
Average per-flow MMF rate is 0.049475
export OMP_NUM_THREADS=4
Simulating XGFT with parameters: height = 3
  m = [18, 18, 36]
  w = [1, 18, 18]
  bw = [1, 1, 1]
sizeL[0] = 11664
sizeL[1] = 648
sizeL[2] = 648
sizeL[3] = 324
baseL[0] = 0
baseL[1] = 11664
baseL[2] = 12312
baseL[3] = 12960
11664 PEs, 1620 switches, 13284 nodes (switch+PE)
Routing algorithm: KPATH
Time to initialize: 2.203508
Time to read from input: 0.045825
Paths processed during input 233264
Time to run iterative algo: 137.649589, #iterations = 12065
Time to calculate final mmf_bw: 0.044316
total elapsed time at MMF: 139.943238
Average per-flow MMF rate is 0.049475
export OMP_NUM_THREADS=3
Simulating XGFT with parameters: height = 3
  m = [18, 18, 36]
  w = [1, 18, 18]
  bw = [1, 1, 1]

sizeL[0] = 11664
sizeL[1] = 648
sizeL[2] = 648
sizeL[3] = 324
baseL[0] = 0
baseL[1] = 11664
baseL[2] = 12312
baseL[3] = 12960
11664 PEs, 1620 switches, 13284 nodes (switch+PE)
Routing algorithm: KPATH
Time to initialize: 2.234209
Time to read from input: 0.044521
Paths processed during input 233264
Time to run iterative algo: 134.442188, #iterations = 12065
Time to calculate final mmf_bw: 0.042633
total elapsed time at MMF: 136.763551
Average per-flow MMF rate is 0.049475
export OMP_NUM_THREADS=2
Simulating XGFT with parameters: height = 3
  m = [18, 18, 36]
  w = [1, 18, 18]
  bw = [1, 1, 1]
sizeL[0] = 11664
sizeL[1] = 648
sizeL[2] = 648
sizeL[3] = 324
baseL[0] = 0
baseL[1] = 11664
baseL[2] = 12312
baseL[3] = 12960
11664 PEs, 1620 switches, 13284 nodes (switch+PE)
Routing algorithm: KPATH
Time to initialize: 2.217025
Time to read from input: 0.045545
Paths processed during input 233264
Time to run iterative algo: 186.072170, #iterations = 12065
Time to calculate final mmf_bw: 0.043483
total elapsed time at MMF: 188.378223
Average per-flow MMF rate is 0.049475
export OMP_NUM_THREADS=1
Simulating XGFT with parameters: height = 3
  m = [18, 18, 36]
  w = [1, 18, 18]

```
  bw = [1, 1, 1]
sizeL[0] = 11664
sizeL[1] = 648
sizeL[2] = 648
sizeL[3] = 324
baseL[0] = 0
baseL[1] = 11664
baseL[2] = 12312
baseL[3] = 12960
11664 PEs, 1620 switches, 13284 nodes (switch+PE)
Routing algorithm: KPATH
Time to initialize: 2.228101
Time to read from input: 0.044503
Paths processed during input 233264
Time to run iterative algo: 327.123288, #iterations = 12065
Time to calculate final mmf_bw: 0.043060
total elapsed time at MMF: 329.438952
Average per-flow MMF rate is 0.049475
```