ANSWERS.md

Basic info about running platform

Instead of copy pasting the same machine specification we'll just specify the name of the machine next to the results

System - "Main machine"

- Time of this report: 9/18/2018, 17:43:26
- Operating System: Windows 10 Pro 64-bit
- System Manufacturer: Dell Inc.
- System Model: Inspiron 7559
- BIOS: 1.2.2 (type: UEFI)
- Processor: Intel(R) Core(TM) i7-6700HQ CPU @ 2.60GHz (8 CPUs), ~2.6GHz
- Memory: 16384MB RAM
- Available OS Memory: 16256MB RAM

System - "Jet Engine"

- Date: 2018-09-17T17:39:20+0200
- OS: Windows 10; 10.0; amd64
- JVM: Oracle Corporation; 10.0.2
- CPU: Intel64 Family 6 Model 60 Stepping 3, GenuineIntel; 8 "cores"
- RAM: 16 GB

Exercise 3.1

Part 1.

Mark01

As written in the in the article the parallelism performed by the CPU lowered the result time into `0.0 ns` . We have decided to lower the number of executions to see whether we get similar results => and indeed we do get similarities described in the `benchmarking`

```
 -----------------------
|Run on - "Main machine"|
 -----------------------
100 => `119.0 ns`
100_000 => `29.9 ns`
100_000_000 runs => `0.0 ns`
```

Mark02

We can see that our result time is slightly lower then the one in `benchmarking` , which is cause (we assume) by having a better platform.

```
 ----------------------
|Run on - "Main machine"|
 ----------------------
 results => `23.2 ns`
```

Mark03

We can observe the same consistancy and similarity with `Mark02`, however the CPU time returned seems to stabilize around `25.5 ns`

```
 ----------------------
|Run on - "Main machine"|
 ----------------------
  23.2 ns
  25.6 ns
  25.6 ns
  26.4 ns
  26.1 ns
  25.5 ns
  25.4 ns
  25.4 ns
  25.5 ns
  25.5 ns
```

Mark04

The result time is slightly lower than the one in `Mark02`, however the consistancy still lingers between `21 - 25 ns`

```
 ----------------------
|Run on - "Main machine"|
 ----------------------
results => `21.2 ns +/-  0.503`
```

Mark05

We can observe similary fashioned results as in the `benchmarking`. We can conclude that test from `Mark01` seems to be proven in a nice list.

```
 ----------------------
|Run on - "Main machine"|
 ----------------------
 345.0 ns +/-   600.21          2
 137.5 ns +/-    84.37          4
 147.5 ns +/-   149.98          8
 137.5 ns +/-   154.48         16
  35.6 ns +/-     7.40         32
  65.0 ns +/-    70.32         64
  76.6 ns +/-    59.48        128
  31.7 ns +/-     2.04        256
  39.8 ns +/-    11.93        512
  40.5 ns +/-     8.03       1024
  32.7 ns +/-     3.52       2048
  32.9 ns +/-     4.06       4096
  32.9 ns +/-     3.34       8192
  33.2 ns +/-     4.74      16384
  31.2 ns +/-    17.39      32768
  29.3 ns +/-     5.57      65536
  21.7 ns +/-     4.72     131072
  20.7 ns +/-     2.11     262144
  20.2 ns +/-     1.39     524288
  20.3 ns +/-     0.79    1048576
  20.2 ns +/-     0.66    2097152
```

```
    20.1 ns +/-     0.25    4194304
    19.9 ns +/-     0.25    8388608
    19.9 ns +/-     0.07   16777216
```

Mark06

We can observe that our running platform was able to perform up to 16,7 million runs with average `22.6 ns` per call and the deviation between 10 calls is `0.14`

```
   -----------------------
  |Run on - "Main machine"|
   -----------------------
  multiply                           510.0 ns    1069.22          2
  multiply                           575.0 ns    1194.78          4
  multiply                           166.3 ns     112.28          8
  multiply                           271.3 ns     348.24         16
  multiply                            72.2 ns      94.34         32
  multiply                            49.7 ns      21.79         64
  multiply                            91.3 ns      69.49        128
  multiply                            43.6 ns       9.65        256
  multiply                            65.4 ns      11.98        512
  multiply                            37.1 ns       4.56       1024
  multiply                            36.0 ns       2.27       2048
  multiply                            38.7 ns       3.62       4096
  multiply                            30.2 ns       3.01       8192
  multiply                            30.4 ns       1.84      16384
  multiply                            27.1 ns       4.01      32768
  multiply                            37.9 ns      14.77      65536
  multiply                            24.0 ns       3.28     131072
  multiply                            24.0 ns       1.26     262144
  multiply                            23.2 ns       1.68     524288
  multiply                            23.0 ns       1.21    1048576
  multiply                            22.9 ns       0.51    2097152
  multiply                            22.6 ns       0.37    4194304
  multiply                            22.7 ns       0.31    8388608
  multiply                            22.6 ns       0.14   16777216
```

Part 2.

Considering part one of this exercise the results seem plausible.

- `pow` => our execution platform made 4 times more calls with lower time results between the calls but higher deviation
- `acos` => result time between the calls is similar as one in the `benchmarking` however deviation is waay higher. This may be affected by number of calls made, which for our platform is 2 times lower.
- `atan` => same number of calls, somewhat close result time but again deviation is waaay higher

```
   -----------------------
  |Run on - "Main machine"|
   -----------------------
  pow                                 23.4 ns       1.27   16777216
  exp                                 23.6 ns       0.15   16777216
  log                                 12.4 ns       0.06   33554432
  sin                                 16.4 ns       0.40   16777216
  cos                                 15.8 ns       0.52   16777216
  tan                                 21.9 ns       0.69   16777216
  asin                               232.8 ns       3.95    2097152
  acos                               230.2 ns      15.73    1048576
  atan                                47.2 ns       1.47    8388608
```

Exercise 3.2

Part 1.

- `hashCode()` => result time got very fast and deviation very small with increased number of calls
- `Point creation` => by group's experience, we expected this to be heavier operation, which is proven by relatively high result time `64.1 ns` and deviation `1.15` for `4194304` calls
- `Thread's work` => this is expected to have least runtime from all of the "threads" measurements except creation of the thread.
- `Thread create` => relatively heavy operation compared to let's say point creation
- `Thread create start` => we did not expected that the starting of the thread would increase result time and deviation so drastically.
- `Thread create start join` => this was expected to take the most work to complete as it performs all of the "thread" measurements before
- `Uncontended lock` => relativly light operation, which seems to be really consistent after couple of calls all the way until the end of the measurement

Part 2.

```
 -----------------------
|Run on - "Main machine"|
 -----------------------
hashCode()                          2.7 ns       0.02  134217728
Point creation                     65.4 ns       0.87    4194304
Thread's work                    5400.8 ns      45.99      65536
Thread create                     911.3 ns     111.43     524288
Thread create start             95256.7 ns    3952.53       4096
Thread create start join       194481.8 ns    7644.20       2048
Uncontended lock                    5.5 ns       0.52   67108864


 -----------------------
|Run on - "Jet Engine"|
 -----------------------
hashCode()                          2.4 ns       0.00  134217728
Point creation                     62.6 ns       0.26    4194304
Thread's work                    5042.3 ns       4.02      65536
Thread create                     818.1 ns      99.30     524288
Thread create start            137040.2 ns     593.13       2048
Thread create start join       232831.9 ns     599.28       2048
ai value = 1392580000
Uncontended lock                    4.4 ns       0.61   67108864
```

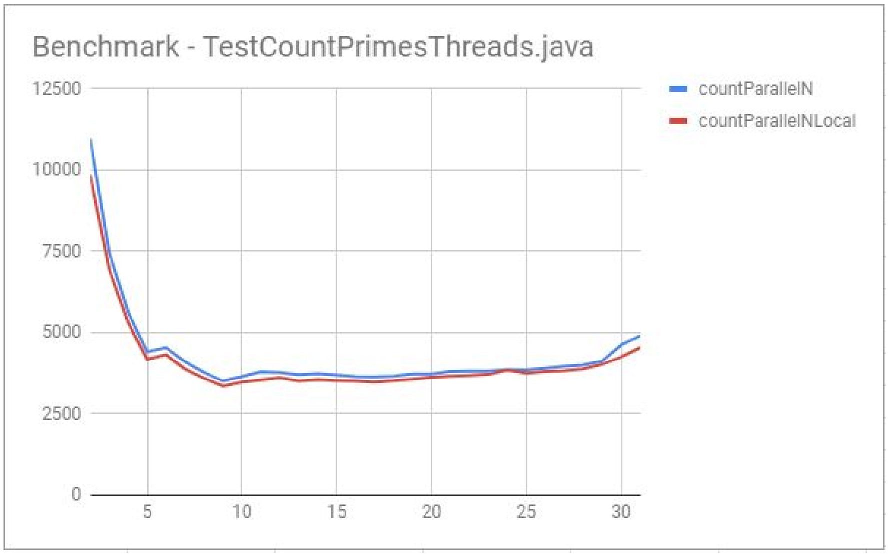
Exercise 3.3

Part 1.

```
countSequential                  9717.4 us     324.81         32
countParallelN      1           10959.7 us     255.06         32
countParallelNLocal      1         9847.3 us     150.60         32
countParallelN      2            7470.9 us     114.03         64
countParallelNLocal      2         6952.6 us     161.13         64
countParallelN      3            5634.6 us      72.63         64
countParallelNLocal      3         5312.1 us      79.59         64
countParallelN      4            4403.8 us     117.83         64
countParallelNLocal      4         4173.0 us     144.46         64
countParallelN      5            4533.0 us     107.24         64
countParallelNLocal      5         4315.7 us     113.51         64
countParallelN      6            4103.5 us      80.75         64
countParallelNLocal      6         3875.4 us      84.33        128
```

```
countParallelN      7             3771.2 us     136.94        128
countParallelNLocal      7         3594.8 us      52.97        128
countParallelN      8             3507.9 us     51.82        128
countParallelNLocal      8         3351.9 us      40.23        128
countParallelN      9             3646.7 us     65.22        128
countParallelNLocal      9         3478.8 us      43.97        128
countParallelN     10             3794.4 us    137.67        128
countParallelNLocal     10         3546.3 us      52.40        128
countParallelN     11             3768.3 us     48.85        128
countParallelNLocal     11         3611.8 us      59.16        128
countParallelN     12             3705.7 us     39.28        128
countParallelNLocal     12         3514.2 us      53.43        128
countParallelN     13             3740.7 us     41.33        128
countParallelNLocal     13         3554.6 us      42.14        128
countParallelN     14             3690.9 us     49.24        128
countParallelNLocal     14         3527.6 us      38.33        128
countParallelN     15             3646.1 us     42.41        128
countParallelNLocal     15         3511.2 us      49.41        128
countParallelN     16             3639.1 us     70.27        128
countParallelNLocal     16         3480.2 us      52.71        128
countParallelN     17             3653.9 us     55.93        128
countParallelNLocal     17         3517.6 us      71.03        128
countParallelN     18             3719.4 us     53.60        128
countParallelNLocal     18         3570.9 us      47.53        128
countParallelN     19             3719.9 us     35.17        128
countParallelNLocal     19         3618.5 us      62.79        128
countParallelN     20             3806.9 us    114.98         64
countParallelNLocal     20         3652.8 us      83.87        128
countParallelN     21             3809.3 us     51.35        128
countParallelNLocal     21         3681.2 us      69.94        128
countParallelN     22             3820.1 us     57.93        128
countParallelNLocal     22         3708.4 us      51.48        128
countParallelN     23             3856.7 us     78.59        128
countParallelNLocal     23         3845.4 us     250.96        128
countParallelN     24             3848.8 us     63.68        128
countParallelNLocal     24         3748.2 us      91.82         64
countParallelN     25             3901.8 us     61.90        128
countParallelNLocal     25         3807.0 us      65.78        128
countParallelN     26             3961.5 us     80.46         64
countParallelNLocal     26         3825.6 us      89.45        128
countParallelN     27             4002.4 us     88.58         64
countParallelNLocal     27         3880.4 us      71.93        128
countParallelN     28             4123.5 us    181.32         64
countParallelNLocal     28         4025.4 us     124.40         64
countParallelN     29             4618.1 us    401.48         64
countParallelNLocal     29         4248.9 us     298.49         64
countParallelN     30             4903.0 us    311.60         64
countParallelNLocal     30         4536.0 us     188.44         64
countParallelN     31             4506.1 us    172.48         64
countParallelNLocal     31         4773.0 us     295.86         64
countParallelN     32             4607.6 us    164.94         64
countParallelNLocal     32         4472.4 us     143.61         64
```

Part 2.

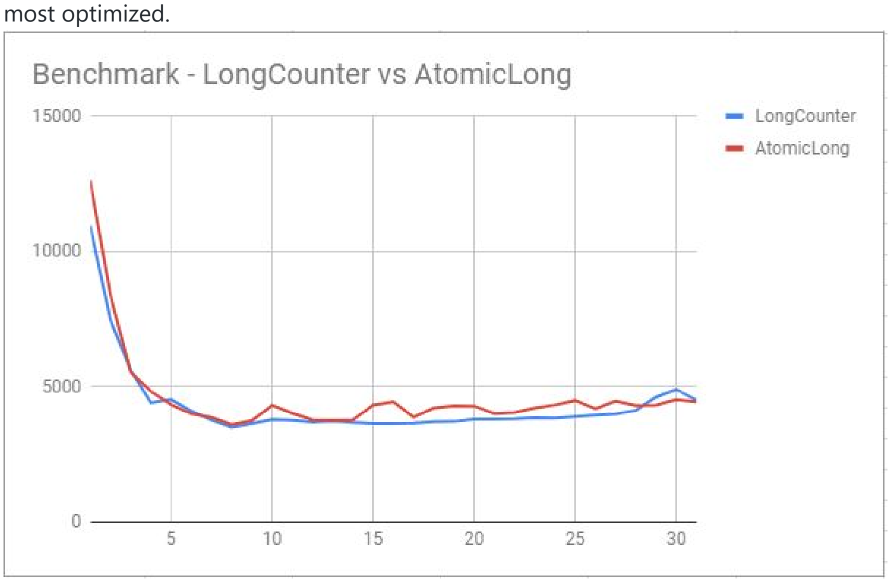


Part 3.

The results seem plausible. We can see that lowest runtime was with 8 threads which nicely corresponds to the number of cores on the platform.

Part 4.

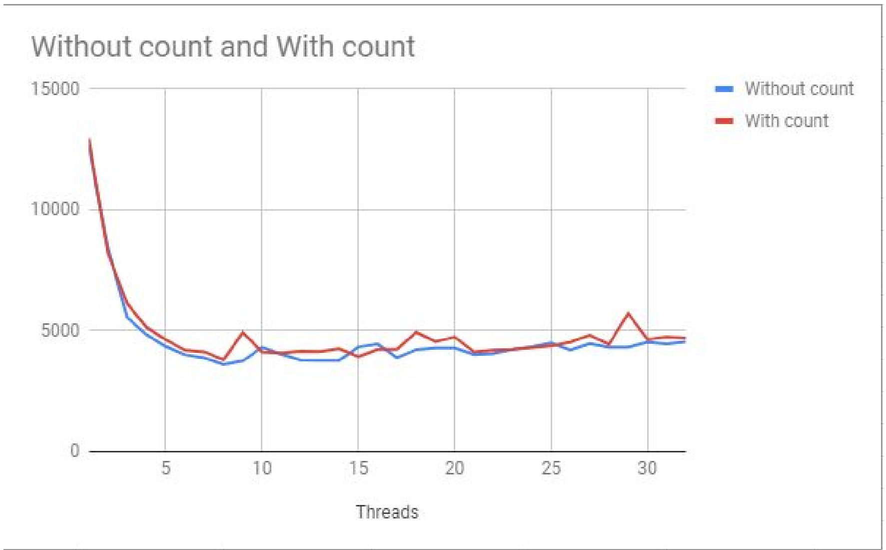
It does not seem that the `AtomicLong` performed much better. One should generally use build in helpers as they are usually most optimized.




```
countSequential                  11343.8 us     210.28         32
countParallelN      1            12621.9 us     421.09         32
countParallelNLocal      1        12091.0 us     655.20         32
countParallelN      2             8397.6 us     501.94         32
countParallelNLocal      2         7687.8 us     326.20         64
countParallelN      3             5537.6 us     136.25         64
countParallelNLocal      3         5764.6 us     104.79         64
countParallelN      4             4834.7 us     157.98         64
countParallelNLocal      4         5107.7 us      86.98         64
countParallelN      5             4343.1 us      74.64         64
countParallelNLocal      5         4521.6 us      80.69         64
countParallelN      6             4002.9 us      76.58         64
countParallelNLocal      6         4317.2 us     150.01         64
countParallelN      7             3872.9 us     133.35         64
countParallelNLocal      7         4018.6 us     164.85         64
```

```
countParallelN      8             3610.9 us      70.10        128
countParallelNLocal      8         3680.1 us      67.85        128
countParallelN      9             3753.9 us      75.18        128
countParallelNLocal      9         3844.6 us      59.19        128
countParallelN     10             4312.6 us     413.00         64
countParallelNLocal     10         4137.2 us     208.71         64
countParallelN     11             4025.7 us     245.90         64
countParallelNLocal     11         4116.4 us     300.70         64
countParallelN     12             3783.7 us      30.03        128
countParallelNLocal     12         3870.5 us      40.87        128
countParallelN     13             3766.1 us      39.25        128
countParallelNLocal     13         3839.1 us      45.61         64
countParallelN     14             3774.5 us      89.95        128
countParallelNLocal     14         3757.2 us      43.88        128
countParallelN     15             4322.1 us     460.74         64
countParallelNLocal     15         4729.8 us     516.31         64
countParallelN     16             4445.2 us     425.57        128
countParallelNLocal     16         4046.9 us     206.38         64
countParallelN     17             3883.7 us      87.16         64
countParallelNLocal     17         4162.2 us     230.79         64
countParallelN     18             4212.0 us     343.34        128
countParallelNLocal     18         4070.3 us     100.67         64
countParallelN     19             4290.9 us     188.31         64
countParallelNLocal     19         4153.4 us     289.48         64
countParallelN     20             4284.3 us     204.46         64
countParallelNLocal     20         4292.5 us     224.66         64
countParallelN     21             4013.2 us     121.64         64
countParallelNLocal     21         4070.3 us      89.31         64
countParallelN     22             4055.9 us     112.56         64
countParallelNLocal     22         4172.0 us     210.07         64
countParallelN     23             4217.8 us     242.38         64
countParallelNLocal     23         4364.8 us     222.57         64
countParallelN     24             4328.0 us     223.61         64
countParallelNLocal     24         4403.0 us     230.42         64
countParallelN     25             4488.0 us     334.32         64
countParallelNLocal     25         4232.7 us     134.25         64
countParallelN     26             4194.4 us     142.11         64
countParallelNLocal     26         4387.9 us     145.40         64
countParallelN     27             4462.9 us     202.43         64
countParallelNLocal     27         4650.8 us     332.43         64
countParallelN     28             4310.0 us     100.38         64
countParallelNLocal     28         4361.1 us     205.17         64
countParallelN     29             4320.8 us     123.94         64
countParallelNLocal     29         4847.2 us    1172.27         32
countParallelN     30             4519.4 us     163.24         64
countParallelNLocal     30         4665.0 us     552.00         64
countParallelN     31             4446.5 us     100.61         64
countParallelNLocal     31         4580.3 us     171.59         64
countParallelN     32             4536.3 us      95.21         64
countParallelNLocal     32         4566.1 us     135.05         64
```

Part 5.



It seems to be slower.

```
countSequential                     11617.1 us     280.84          32
countParallelN       1              12956.4 us     358.59          32
countParallelNLocal       1          12362.5 us     615.54          32
countParallelN       2               8203.4 us     131.86          32
countParallelNLocal       2           7911.9 us     302.01          64
countParallelN       3               6117.9 us     323.20          64
countParallelNLocal       3           5968.3 us     342.40          64
countParallelN       4               5136.8 us     125.38          64
countParallelNLocal       4           5009.9 us      81.44          64
countParallelN       5               4620.9 us     149.78          64
countParallelNLocal       5           4620.1 us     138.86          64
countParallelN       6               4188.6 us      56.08          64
countParallelNLocal       6           4170.0 us      62.93          64
countParallelN       7               4124.4 us     135.99          64
countParallelNLocal       7           3928.8 us     103.28          64
countParallelN       8               3804.4 us      88.44         128
countParallelNLocal       8           4433.5 us     745.28          64
countParallelN       9               4913.2 us     240.33          64
countParallelNLocal       9           4800.9 us     464.80          64
countParallelN      10               4115.1 us     229.96          64
countParallelNLocal      10           4172.8 us     231.16          64
countParallelN      11               4076.7 us      89.61          64
countParallelNLocal      11           4183.2 us     158.18          64
countParallelN      12               4147.2 us     200.84         128
countParallelNLocal      12           4241.6 us     233.07          64
countParallelN      13               4129.7 us     232.57          64
countParallelNLocal      13           4153.0 us     257.66          64
countParallelN      14               4247.3 us     327.65         128
countParallelNLocal      14           4226.6 us     271.72          64
countParallelN      15               3926.1 us      75.72          64
countParallelNLocal      15           4156.2 us     257.04          64
countParallelN      16               4218.3 us     244.50          64
countParallelNLocal      16           3901.1 us     113.59          64
countParallelN      17               4219.9 us     258.01          64
countParallelNLocal      17           4113.3 us     259.23          64
countParallelN      18               4936.5 us     682.63          64
countParallelNLocal      18           4638.1 us     745.18          64
countParallelN      19               4550.1 us     167.57          64
countParallelNLocal      19           4436.6 us     200.99          64
countParallelN      20               4738.8 us     689.16          64
countParallelNLocal      20           4455.9 us     336.87          64
countParallelN      21               4119.1 us      91.59          64
countParallelNLocal      21           4182.1 us     137.57          64
countParallelN      22               4190.0 us     139.34          64
countParallelNLocal      22           4266.5 us     184.64          64
countParallelN      23               4230.9 us      82.57          64
countParallelNLocal      23           4264.9 us     168.74          64
countParallelN      24               4304.9 us     200.03          64
```

```
countParallelNLocal     24          4258.5 us     204.91         64
countParallelN     25              4368.0 us     220.70         64
countParallelNLocal     25          4494.0 us     382.03         64
countParallelN     26              4528.5 us     311.13         64
countParallelNLocal     26          4448.4 us     169.13         64
countParallelN     27              4806.1 us     402.12         64
countParallelNLocal     27          4628.5 us     266.74         64
countParallelN     28              4438.3 us     214.75         64
countParallelNLocal     28          4637.2 us     168.85         64
countParallelN     29              5711.2 us     638.89         64
countParallelNLocal     29          4602.2 us     123.57         64
countParallelN     30              4638.7 us      69.37         64
countParallelNLocal     30          4915.0 us     716.66         64
countParallelN     31              4736.1 us     314.77         64
countParallelNLocal     31          5021.4 us     505.33         64
countParallelN     32              4692.3 us     114.92         64
countParallelNLocal     32          4763.6 us     129.21         64
```

Exercise 3.4

Part 1.

Memoizer1 => `Results 3.9 s 0.12 2`

Part 2.

Memoizer2 => `Results 2.0 s 0.05 2`

Part 3.

Memoizer3 => `Results 1.8 s 0.04 2`

Part 4.

Memoizer4 => `Results 1.8 s 0.04 2`

Part 5.

Memoizer5 => `Results 1.7 s 0.03 2`

Part 6.

Memoizer0 => `Results 1.8 s 0.03 2`

Part 7.

`Memoizer5` performed the best, with checking the cache if it exists before saving it. The results agree with lecture's and Goetz's development of the cache classes.

Part 8.

The current tests are running on empty caches, so we were thinking on running the tests for 3 different stages of cache - empty, randomized, predefined. This way we can have more data on how are the cache implementations running with either empty or filled storages.