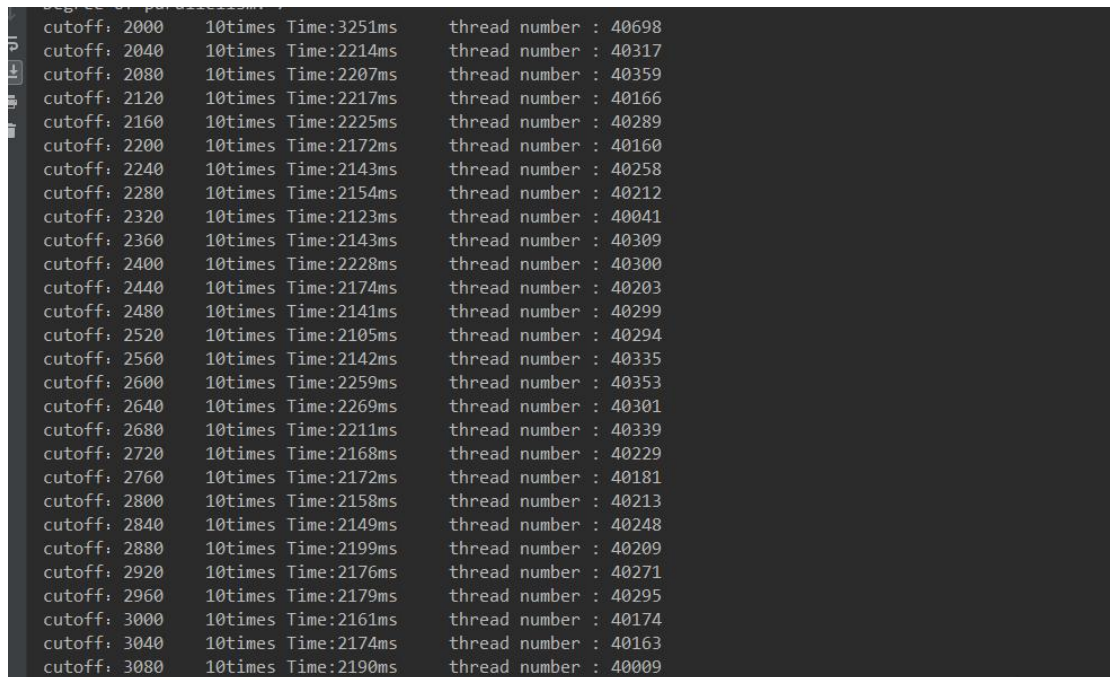


# Assignment 4

## 1. Observation

### 1) When array size is 4000000



cutoff: 2000	10times	Time:3251ms	thread number : 40698
cutoff: 2040	10times	Time:2214ms	thread number : 40317
cutoff: 2080	10times	Time:2207ms	thread number : 40359
cutoff: 2120	10times	Time:2217ms	thread number : 40166
cutoff: 2160	10times	Time:2225ms	thread number : 40289
cutoff: 2200	10times	Time:2172ms	thread number : 40160
cutoff: 2240	10times	Time:2143ms	thread number : 40258
cutoff: 2280	10times	Time:2154ms	thread number : 40212
cutoff: 2320	10times	Time:2123ms	thread number : 40041
cutoff: 2360	10times	Time:2143ms	thread number : 40309
cutoff: 2400	10times	Time:2228ms	thread number : 40300
cutoff: 2440	10times	Time:2174ms	thread number : 40203
cutoff: 2480	10times	Time:2141ms	thread number : 40299
cutoff: 2520	10times	Time:2105ms	thread number : 40294
cutoff: 2560	10times	Time:2142ms	thread number : 40335
cutoff: 2600	10times	Time:2259ms	thread number : 40353
cutoff: 2640	10times	Time:2269ms	thread number : 40301
cutoff: 2680	10times	Time:2211ms	thread number : 40339
cutoff: 2720	10times	Time:2168ms	thread number : 40229
cutoff: 2760	10times	Time:2172ms	thread number : 40181
cutoff: 2800	10times	Time:2158ms	thread number : 40213
cutoff: 2840	10times	Time:2149ms	thread number : 40248
cutoff: 2880	10times	Time:2199ms	thread number : 40209
cutoff: 2920	10times	Time:2176ms	thread number : 40271
cutoff: 2960	10times	Time:2179ms	thread number : 40295
cutoff: 3000	10times	Time:2161ms	thread number : 40174
cutoff: 3040	10times	Time:2174ms	thread number : 40163
cutoff: 3080	10times	Time:2190ms	thread number : 40009

And when cutoff is smaller than about 2000, I can't get the results because it costs too much time.

### 2) When array size is 2000000

```
Run: Main x Main x
"C:\Program Files\Java\jdk-10.0.2\bin\java.exe" "-javaagent:D:\IntelliJ IDEA 2018.2.1\lib\
Degree of parallelism: 7
cutoff: 5100 10times Time:1940ms
cutoff: 5200 10times Time:1063ms
cutoff: 5300 10times Time:1012ms
cutoff: 5400 10times Time:1017ms
cutoff: 5500 10times Time:1017ms
cutoff: 5600 10times Time:1062ms
cutoff: 5700 10times Time:1011ms
cutoff: 5800 10times Time:1031ms
cutoff: 5900 10times Time:1010ms
cutoff: 6000 10times Time:1020ms
cutoff: 6100 10times Time:1034ms
cutoff: 6200 10times Time:1050ms
cutoff: 6300 10times Time:1050ms
cutoff: 6400 10times Time:1031ms
cutoff: 6500 10times Time:1012ms
cutoff: 6600 10times Time:1025ms
cutoff: 6700 10times Time:1002ms
cutoff: 6800 10times Time:1015ms
cutoff: 6900 10times Time:980ms
cutoff: 7000 10times Time:1003ms
cutoff: 7100 10times Time:1017ms
cutoff: 7200 10times Time:1040ms
cutoff: 7300 10times Time:999ms
cutoff: 7400 10times Time:1001ms
cutoff: 7500 10times Time:991ms
cutoff: 7600 10times Time:990ms
cutoff: 7700 10times Time:1001ms
cutoff: 7800 10times Time:1001ms
cutoff: 7900 10times Time:957ms
```

```
cutoff: 1000 10times Time:1940ms thread number : 40571
cutoff: 1020 10times Time:1279ms thread number : 40241
cutoff: 1040 10times Time:1072ms thread number : 39616
cutoff: 1060 10times Time:1074ms thread number : 39352
cutoff: 1080 10times Time:1041ms thread number : 39521
cutoff: 1100 10times Time:1047ms thread number : 39660
cutoff: 1120 10times Time:1083ms thread number : 39815
cutoff: 1140 10times Time:1126ms thread number : 39632
cutoff: 1160 10times Time:1086ms thread number : 39680
cutoff: 1180 10times Time:1054ms thread number : 39471
cutoff: 1200 10times Time:1090ms thread number : 39753
cutoff: 1220 10times Time:1061ms thread number : 39389
cutoff: 1240 10times Time:1099ms thread number : 39363
cutoff: 1260 10times Time:1061ms thread number : 39425
cutoff: 1280 10times Time:1054ms thread number : 39369
cutoff: 1300 10times Time:1050ms thread number : 39418
cutoff: 1320 10times Time:1060ms thread number : 39185
cutoff: 1340 10times Time:1061ms thread number : 39590
cutoff: 1360 10times Time:1086ms thread number : 39530
cutoff: 1380 10times Time:1053ms thread number : 39318
cutoff: 1400 10times Time:1065ms thread number : 39073
cutoff: 1420 10times Time:1049ms thread number : 39143
cutoff: 1440 10times Time:1071ms thread number : 39157
cutoff: 1460 10times Time:1171ms thread number : 39835
cutoff: 1480 10times Time:1150ms thread number : 39280
cutoff: 1500 10times Time:1143ms thread number : 39666
cutoff: 1520 10times Time:1087ms thread number : 39361
cutoff: 1540 10times Time:1129ms thread number : 39516
cutoff: 1560 10times Time:1090ms thread number : 39625
cutoff: 1580 10times Time:1183ms thread number : 39895
```

And when cutoff is smaller than about 1000, I can't get the results because it costs too much time.

### 3) When array size is 1000000

```
Run: Main x Main x
"C:\Program Files\Java\jdk-10.0.2\bin\java.exe" "-javaagent:D:\IntelliJ IDEA 2018.2.1\lib\idea_rt.jar=50597:D:\Int
Degree of parallelism: 7
cutoff: 5100 10times Time:1189ms
cutoff: 5200 10times Time:570ms
cutoff: 5300 10times Time:537ms
cutoff: 5400 10times Time:471ms
cutoff: 5500 10times Time:464ms
cutoff: 5600 10times Time:478ms
cutoff: 5700 10times Time:464ms
cutoff: 5800 10times Time:460ms
cutoff: 5900 10times Time:465ms
cutoff: 6000 10times Time:459ms
cutoff: 6100 10times Time:458ms
cutoff: 6200 10times Time:493ms
cutoff: 6300 10times Time:477ms
cutoff: 6400 10times Time:474ms
cutoff: 6500 10times Time:462ms
cutoff: 6600 10times Time:457ms
cutoff: 6700 10times Time:457ms
cutoff: 6800 10times Time:456ms
cutoff: 6900 10times Time:461ms
cutoff: 7000 10times Time:457ms
cutoff: 7100 10times Time:470ms
cutoff: 7200 10times Time:454ms
cutoff: 7300 10times Time:455ms
cutoff: 7400 10times Time:460ms
cutoff: 7500 10times Time:460ms
cutoff: 7600 10times Time:459ms
cutoff: 7700 10times Time:461ms
cutoff: 7800 10times Time:482ms
cutoff: 7900 10times Time:476ms
cutoff: 8000 10times Time:455ms
```

```

cutoff: 650 10times Time:944ms thread number : 40427
cutoff: 663 10times Time:690ms thread number : 39995
cutoff: 676 10times Time:764ms thread number : 39249
cutoff: 689 10times Time:586ms thread number : 39118
cutoff: 702 10times Time:643ms thread number : 40018
cutoff: 715 10times Time:590ms thread number : 38589
cutoff: 728 10times Time:604ms thread number : 37996
cutoff: 741 10times Time:537ms thread number : 38066
cutoff: 754 10times Time:553ms thread number : 37945
cutoff: 767 10times Time:511ms thread number : 37644
cutoff: 780 10times Time:529ms thread number : 38182
cutoff: 793 10times Time:528ms thread number : 37623
cutoff: 806 10times Time:521ms thread number : 38022
cutoff: 819 10times Time:530ms thread number : 38257
cutoff: 832 10times Time:531ms thread number : 37799
cutoff: 845 10times Time:544ms thread number : 38251
cutoff: 858 10times Time:560ms thread number : 38949
cutoff: 871 10times Time:531ms thread number : 38203
cutoff: 884 10times Time:538ms thread number : 38180
cutoff: 897 10times Time:525ms thread number : 38700
cutoff: 910 10times Time:526ms thread number : 37298
cutoff: 923 10times Time:529ms thread number : 37855
cutoff: 936 10times Time:539ms thread number : 38706
cutoff: 949 10times Time:535ms thread number : 38077
cutoff: 962 10times Time:524ms thread number : 38190
cutoff: 975 10times Time:571ms thread number : 38787
cutoff: 988 10times Time:531ms thread number : 19723
cutoff: 1001 10times Time:520ms thread number : 19738
cutoff: 1014 10times Time:506ms thread number : 19589
cutoff: 1027 10times Time:520ms thread number : 19793
cutoff: 1040 10times Time:513ms thread number : 19652
cutoff: 1053 10times Time:502ms thread number : 19604
cutoff: 1066 10times Time:508ms thread number : 19552
cutoff: 1079 10times Time:514ms thread number : 19552
```

And when cutoff is smaller than about 650, I can't get the results because it costs too much time.

### 4) When array size is 500000



```
Run: Main x Main x
|C:\Program Files\Java\jdk-10.0.2\bin\java.exe" "-javaagent:D:\IntelliJ IDEA 2018.2.1\lib\idea_rt.jar=50777:D:\Int
Degree of parallelism: 7
cutoff: 5100 10times Time:544ms
cutoff: 5200 10times Time:293ms
cutoff: 5300 10times Time:376ms
cutoff: 5400 10times Time:252ms
cutoff: 5500 10times Time:226ms
cutoff: 5600 10times Time:220ms
cutoff: 5700 10times Time:222ms
cutoff: 5800 10times Time:220ms
cutoff: 5900 10times Time:218ms
cutoff: 6000 10times Time:222ms
cutoff: 6100 10times Time:219ms
cutoff: 6200 10times Time:222ms
cutoff: 6300 10times Time:217ms
cutoff: 6400 10times Time:219ms
cutoff: 6500 10times Time:222ms
cutoff: 6600 10times Time:240ms
cutoff: 6700 10times Time:232ms
cutoff: 6800 10times Time:216ms
cutoff: 6900 10times Time:218ms
cutoff: 7000 10times Time:220ms
cutoff: 7100 10times Time:236ms
cutoff: 7200 10times Time:231ms
cutoff: 7300 10times Time:250ms
cutoff: 7400 10times Time:224ms
cutoff: 7500 10times Time:237ms
cutoff: 7600 10times Time:216ms
cutoff: 7700 10times Time:219ms
cutoff: 7800 10times Time:217ms
cutoff: 7900 10times Time:214ms
cutoff: 8000 10times Time:215ms
cutoff: 8100 10times Time:209ms
cutoff: 8200 10times Time:217ms
cutoff: 8300 10times Time:210ms
cutoff: 8400 10times Time:260ms
cutoff: 8500 10times Time:213ms
cutoff: 8600 10times Time:221ms
cutoff: 8700 10times Time:216ms
```

```
degree of parallelism: 7
cutoff: 500 10times Time:770ms thread number : 20351
cutoff: 510 10times Time:356ms thread number : 20189
cutoff: 520 10times Time:358ms thread number : 20188
cutoff: 530 10times Time:371ms thread number : 20424
cutoff: 540 10times Time:325ms thread number : 19658
cutoff: 550 10times Time:249ms thread number : 18967
cutoff: 560 10times Time:248ms thread number : 18940
cutoff: 570 10times Time:246ms thread number : 19448
cutoff: 580 10times Time:249ms thread number : 19371
cutoff: 590 10times Time:301ms thread number : 19325
cutoff: 600 10times Time:260ms thread number : 19210
cutoff: 610 10times Time:261ms thread number : 19552
cutoff: 620 10times Time:252ms thread number : 19344
cutoff: 630 10times Time:250ms thread number : 19252
cutoff: 640 10times Time:295ms thread number : 19160
cutoff: 650 10times Time:251ms thread number : 19182
cutoff: 660 10times Time:255ms thread number : 19460
cutoff: 670 10times Time:251ms thread number : 18950
cutoff: 680 10times Time:245ms thread number : 19014
cutoff: 690 10times Time:251ms thread number : 19383
cutoff: 700 10times Time:240ms thread number : 18917
cutoff: 710 10times Time:249ms thread number : 19194
cutoff: 720 10times Time:250ms thread number : 19174
cutoff: 730 10times Time:258ms thread number : 19433
cutoff: 740 10times Time:252ms thread number : 19460
cutoff: 750 10times Time:247ms thread number : 19095
cutoff: 760 10times Time:263ms thread number : 19376
cutoff: 770 10times Time:263ms thread number : 19467
cutoff: 780 10times Time:248ms thread number : 19163
cutoff: 790 10times Time:246ms thread number : 19068
cutoff: 800 10times Time:250ms thread number : 19450
cutoff: 810 10times Time:244ms thread number : 19371
cutoff: 820 10times Time:250ms thread number : 19136
cutoff: 830 10times Time:245ms thread number : 19483
cutoff: 840 10times Time:250ms thread number : 19356
```

And when cutoff is smaller than about 500, I can't get the results because it costs too much time.

5) When array size is 250000

```
Run: Main x Main x
"C:\Program Files\Java\jdk-10.0.2\bin\java.exe" "-javaagent:D:\IntelliJ IDEA 2018.2.1\lib\idea_rt.jar"
Degree of parallelism: 7
cutoff: 5100 10times Time:352ms
cutoff: 5200 10times Time:224ms
cutoff: 5300 10times Time:165ms
cutoff: 5400 10times Time:170ms
cutoff: 5500 10times Time:129ms
cutoff: 5600 10times Time:135ms
cutoff: 5700 10times Time:130ms
cutoff: 5800 10times Time:121ms
cutoff: 5900 10times Time:115ms
cutoff: 6000 10times Time:109ms
cutoff: 6100 10times Time:110ms
cutoff: 6200 10times Time:113ms
cutoff: 6300 10times Time:114ms
cutoff: 6400 10times Time:104ms
cutoff: 6500 10times Time:104ms
cutoff: 6600 10times Time:117ms
cutoff: 6700 10times Time:112ms
cutoff: 6800 10times Time:107ms
cutoff: 6900 10times Time:107ms
cutoff: 7000 10times Time:105ms
cutoff: 7100 10times Time:108ms
cutoff: 7200 10times Time:105ms
cutoff: 7300 10times Time:105ms
cutoff: 7400 10times Time:111ms
cutoff: 7500 10times Time:106ms
cutoff: 7600 10times Time:106ms
cutoff: 7700 10times Time:102ms
cutoff: 7800 10times Time:103ms
cutoff: 7900 10times Time:102ms
```

```

cutoff: 250 10times Time:365ms thread number : 20320
cutoff: 255 10times Time:153ms thread number : 19023
cutoff: 260 10times Time:152ms thread number : 19027
cutoff: 265 10times Time:131ms thread number : 17674
cutoff: 270 10times Time:169ms thread number : 18921
cutoff: 275 10times Time:193ms thread number : 19010
cutoff: 280 10times Time:170ms thread number : 19889
cutoff: 285 10times Time:148ms thread number : 18861
cutoff: 290 10times Time:131ms thread number : 19200
cutoff: 295 10times Time:121ms thread number : 16858
cutoff: 300 10times Time:122ms thread number : 17563
cutoff: 305 10times Time:119ms thread number : 17827
cutoff: 310 10times Time:117ms thread number : 17169
cutoff: 315 10times Time:117ms thread number : 17181
cutoff: 320 10times Time:120ms thread number : 17360
cutoff: 325 10times Time:120ms thread number : 17228
cutoff: 330 10times Time:120ms thread number : 17757
cutoff: 335 10times Time:119ms thread number : 18019
cutoff: 340 10times Time:117ms thread number : 18298
cutoff: 345 10times Time:118ms thread number : 17860
cutoff: 350 10times Time:120ms thread number : 18376
cutoff: 355 10times Time:117ms thread number : 17583
cutoff: 360 10times Time:159ms thread number : 16952
cutoff: 365 10times Time:118ms thread number : 16868
cutoff: 370 10times Time:118ms thread number : 16493
cutoff: 375 10times Time:117ms thread number : 17121
cutoff: 380 10times Time:122ms thread number : 17249
cutoff: 385 10times Time:116ms thread number : 17059
cutoff: 390 10times Time:122ms thread number : 17535
```

And when cutoff is smaller than about 250, I can't get the results because it costs too much time.

## 2. Conclusion

It seems like there is a standard cutoff. If choosing a cutoff bigger than the standard one, the time spent won't be much different. Otherwise, it will cost much more time. Besides the standard cutoff is related to the array size and when the array size is doubled, the corresponding standard array size and spent time doubled.