

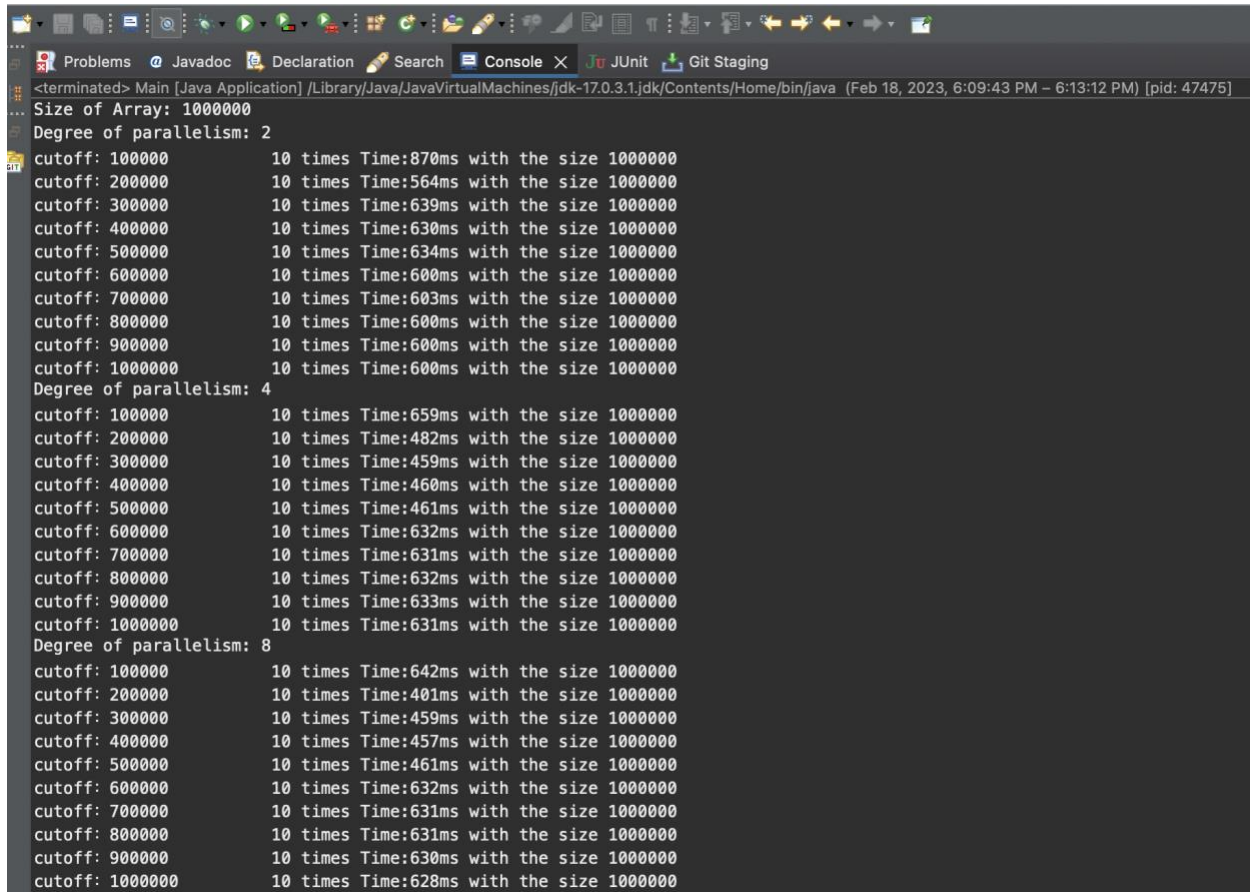
Program Structure and Algorithms
Spring 2023 (Section 8)

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Task: Your task is to implement a parallel sorting algorithm such that each partition of the array is sorted in parallel. You will consider two different schemes for deciding whether to sort in parallel.

Program output:

For Array size 1000000: Thread 2 to Thread 8.



```
<terminated> Main [Java Application] /Library/Java/JavaVirtualMachines/jdk-17.0.3.1.jdk/Contents/Home/bin/java (Feb 18, 2023, 6:09:43 PM – 6:13:12 PM) [pid: 47475]
Size of Array: 1000000
Degree of parallelism: 2
cutoff: 100000      10 times Time:870ms with the size 1000000
cutoff: 200000      10 times Time:564ms with the size 1000000
cutoff: 300000      10 times Time:639ms with the size 1000000
cutoff: 400000      10 times Time:630ms with the size 1000000
cutoff: 500000      10 times Time:634ms with the size 1000000
cutoff: 600000      10 times Time:600ms with the size 1000000
cutoff: 700000      10 times Time:603ms with the size 1000000
cutoff: 800000      10 times Time:600ms with the size 1000000
cutoff: 900000      10 times Time:600ms with the size 1000000
cutoff: 1000000     10 times Time:600ms with the size 1000000
Degree of parallelism: 4
cutoff: 100000      10 times Time:659ms with the size 1000000
cutoff: 200000      10 times Time:482ms with the size 1000000
cutoff: 300000      10 times Time:459ms with the size 1000000
cutoff: 400000      10 times Time:460ms with the size 1000000
cutoff: 500000      10 times Time:461ms with the size 1000000
cutoff: 600000      10 times Time:632ms with the size 1000000
cutoff: 700000      10 times Time:631ms with the size 1000000
cutoff: 800000      10 times Time:632ms with the size 1000000
cutoff: 900000      10 times Time:633ms with the size 1000000
cutoff: 1000000     10 times Time:631ms with the size 1000000
Degree of parallelism: 8
cutoff: 100000      10 times Time:642ms with the size 1000000
cutoff: 200000      10 times Time:401ms with the size 1000000
cutoff: 300000      10 times Time:459ms with the size 1000000
cutoff: 400000      10 times Time:457ms with the size 1000000
cutoff: 500000      10 times Time:461ms with the size 1000000
cutoff: 600000      10 times Time:632ms with the size 1000000
cutoff: 700000      10 times Time:631ms with the size 1000000
cutoff: 800000      10 times Time:631ms with the size 1000000
cutoff: 900000      10 times Time:630ms with the size 1000000
cutoff: 1000000     10 times Time:628ms with the size 1000000
```

For Array size 1000000: Thread 16 to Thread 64.

Program Structure and Algorithms

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```
Problems Javadoc Declaration Search Console X JUnit Git Staging
<terminated> Main [Java Application] /Library/Java/JavaVirtualMachines/jdk-17.0.3.jdk/Contents/Home/bin/java (Feb 18, 2023, 6:09:43 PM - 6:13:12 PM) [pid: 47475]
cutoff: 1000000 10 times Time:620ms with the size 1000000
Degree of parallelism: 16
cutoff: 100000 10 times Time:512ms with the size 1000000
cutoff: 200000 10 times Time:405ms with the size 1000000
cutoff: 300000 10 times Time:461ms with the size 1000000
cutoff: 400000 10 times Time:456ms with the size 1000000
cutoff: 500000 10 times Time:457ms with the size 1000000
cutoff: 600000 10 times Time:631ms with the size 1000000
cutoff: 700000 10 times Time:631ms with the size 1000000
cutoff: 800000 10 times Time:630ms with the size 1000000
cutoff: 900000 10 times Time:630ms with the size 1000000
cutoff: 1000000 10 times Time:628ms with the size 1000000
Degree of parallelism: 32
cutoff: 100000 10 times Time:417ms with the size 1000000
cutoff: 200000 10 times Time:405ms with the size 1000000
cutoff: 300000 10 times Time:458ms with the size 1000000
cutoff: 400000 10 times Time:458ms with the size 1000000
cutoff: 500000 10 times Time:458ms with the size 1000000
cutoff: 600000 10 times Time:630ms with the size 1000000
cutoff: 700000 10 times Time:631ms with the size 1000000
cutoff: 800000 10 times Time:631ms with the size 1000000
cutoff: 900000 10 times Time:626ms with the size 1000000
cutoff: 1000000 10 times Time:631ms with the size 1000000
Degree of parallelism: 64
cutoff: 100000 10 times Time:418ms with the size 1000000
cutoff: 200000 10 times Time:413ms with the size 1000000
cutoff: 300000 10 times Time:457ms with the size 1000000
cutoff: 400000 10 times Time:459ms with the size 1000000
cutoff: 500000 10 times Time:456ms with the size 1000000
cutoff: 600000 10 times Time:634ms with the size 1000000
cutoff: 700000 10 times Time:628ms with the size 1000000
cutoff: 800000 10 times Time:631ms with the size 1000000
cutoff: 900000 10 times Time:634ms with the size 1000000
cutoff: 1000000 10 times Time:632ms with the size 1000000
```

For Array size 2000000: Thread 2 to Thread 8.

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```
<terminated> Main [Java Application] /Library/Java/JavaVirtualMachines/jdk-17.0.3.1.jdk/Contents/Home/bin/java (Feb 18, 2023, 6:09:43 PM – 6:13:12 PM) [pid: 47475]
cutoff: 1000000 10 times Time:632ms with the size 1000000
Size of Array: 2000000
Degree of parallelism: 2
cutoff: 200000 10 times Time:1281ms with the size 2000000
cutoff: 400000 10 times Time:1216ms with the size 2000000
cutoff: 600000 10 times Time:1375ms with the size 2000000
cutoff: 800000 10 times Time:1349ms with the size 2000000
cutoff: 1000000 10 times Time:1359ms with the size 2000000
cutoff: 1200000 10 times Time:1301ms with the size 2000000
cutoff: 1400000 10 times Time:1307ms with the size 2000000
cutoff: 1600000 10 times Time:1304ms with the size 2000000
cutoff: 1800000 10 times Time:1307ms with the size 2000000
cutoff: 2000000 10 times Time:1307ms with the size 2000000
Degree of parallelism: 4
cutoff: 200000 10 times Time:1375ms with the size 2000000
cutoff: 400000 10 times Time:984ms with the size 2000000
cutoff: 600000 10 times Time:937ms with the size 2000000
cutoff: 800000 10 times Time:936ms with the size 2000000
cutoff: 1000000 10 times Time:945ms with the size 2000000
cutoff: 1200000 10 times Time:1305ms with the size 2000000
cutoff: 1400000 10 times Time:1307ms with the size 2000000
cutoff: 1600000 10 times Time:1304ms with the size 2000000
cutoff: 1800000 10 times Time:1307ms with the size 2000000
cutoff: 2000000 10 times Time:1308ms with the size 2000000
Degree of parallelism: 8
cutoff: 200000 10 times Time:1272ms with the size 2000000
cutoff: 400000 10 times Time:801ms with the size 2000000
cutoff: 600000 10 times Time:938ms with the size 2000000
cutoff: 800000 10 times Time:940ms with the size 2000000
cutoff: 1000000 10 times Time:938ms with the size 2000000
cutoff: 1200000 10 times Time:1302ms with the size 2000000
cutoff: 1400000 10 times Time:1303ms with the size 2000000
cutoff: 1600000 10 times Time:1305ms with the size 2000000
cutoff: 1800000 10 times Time:1309ms with the size 2000000
cutoff: 2000000 10 times Time:1301ms with the size 2000000
```

For Array size 2000000: Thread 16 to Thread 64.

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```
<terminated> Main [Java Application] /Library/Java/JavaVirtualMachines/jdk-17.0.3.jdk/Contents/Home/bin/java (Feb 18, 2023, 6:09:43 PM - 6:13:12 PM) [pid: 47475]
cutoff: 2000000 10 times Time:1301ms with the size 2000000
Degree of parallelism: 16
cutoff: 200000 10 times Time:1028ms with the size 2000000
cutoff: 400000 10 times Time:802ms with the size 2000000
cutoff: 600000 10 times Time:941ms with the size 2000000
cutoff: 800000 10 times Time:938ms with the size 2000000
cutoff: 1000000 10 times Time:942ms with the size 2000000
cutoff: 1200000 10 times Time:1300ms with the size 2000000
cutoff: 1400000 10 times Time:1298ms with the size 2000000
cutoff: 1600000 10 times Time:1301ms with the size 2000000
cutoff: 1800000 10 times Time:1301ms with the size 2000000
cutoff: 2000000 10 times Time:1304ms with the size 2000000
Degree of parallelism: 32
cutoff: 200000 10 times Time:828ms with the size 2000000
cutoff: 400000 10 times Time:807ms with the size 2000000
cutoff: 600000 10 times Time:939ms with the size 2000000
cutoff: 800000 10 times Time:942ms with the size 2000000
cutoff: 1000000 10 times Time:938ms with the size 2000000
cutoff: 1200000 10 times Time:1305ms with the size 2000000
cutoff: 1400000 10 times Time:1307ms with the size 2000000
cutoff: 1600000 10 times Time:1307ms with the size 2000000
cutoff: 1800000 10 times Time:1304ms with the size 2000000
cutoff: 2000000 10 times Time:1303ms with the size 2000000
Degree of parallelism: 64
cutoff: 200000 10 times Time:835ms with the size 2000000
cutoff: 400000 10 times Time:799ms with the size 2000000
cutoff: 600000 10 times Time:941ms with the size 2000000
cutoff: 800000 10 times Time:939ms with the size 2000000
cutoff: 1000000 10 times Time:941ms with the size 2000000
cutoff: 1200000 10 times Time:1302ms with the size 2000000
cutoff: 1400000 10 times Time:1310ms with the size 2000000
cutoff: 1600000 10 times Time:1303ms with the size 2000000
cutoff: 1800000 10 times Time:1308ms with the size 2000000
cutoff: 2000000 10 times Time:1300ms with the size 2000000
cutoff: 2000000 ----- 10 times Time:1300ms with the size 2000000
```

For Array size 3000000: Thread 2 to Thread 8.

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```
Problems Javadoc Declaration Search Console X JUnit Git Staging
<terminated> Main [Java Application] /Library/Java/JavaVirtualMachines/jdk-17.0.3.jdk/Contents/Home/bin/java (Feb 18, 2023, 6:09:43 PM - 6:13:12 PM) [pid: 47475]
cutoff: 2000000 10 times Time:1300ms with the size 2000000
Size of Array: 3000000
Degree of parallelism: 2
cutoff: 300000 10 times Time:2018ms with the size 3000000
cutoff: 600000 10 times Time:1852ms with the size 3000000
cutoff: 900000 10 times Time:2078ms with the size 3000000
cutoff: 1200000 10 times Time:2101ms with the size 3000000
cutoff: 1500000 10 times Time:2069ms with the size 3000000
cutoff: 1800000 10 times Time:1999ms with the size 3000000
cutoff: 2100000 10 times Time:1990ms with the size 3000000
cutoff: 2400000 10 times Time:1994ms with the size 3000000
cutoff: 2700000 10 times Time:1992ms with the size 3000000
cutoff: 3000000 10 times Time:1996ms with the size 3000000
Degree of parallelism: 4
cutoff: 300000 10 times Time:1975ms with the size 3000000
cutoff: 600000 10 times Time:1499ms with the size 3000000
cutoff: 900000 10 times Time:1429ms with the size 3000000
cutoff: 1200000 10 times Time:1426ms with the size 3000000
cutoff: 1500000 10 times Time:1424ms with the size 3000000
cutoff: 1800000 10 times Time:1992ms with the size 3000000
cutoff: 2100000 10 times Time:1999ms with the size 3000000
cutoff: 2400000 10 times Time:1995ms with the size 3000000
cutoff: 2700000 10 times Time:1999ms with the size 3000000
cutoff: 3000000 10 times Time:1996ms with the size 3000000
Degree of parallelism: 8
cutoff: 300000 10 times Time:1690ms with the size 3000000
cutoff: 600000 10 times Time:1457ms with the size 3000000
cutoff: 900000 10 times Time:1427ms with the size 3000000
cutoff: 1200000 10 times Time:1428ms with the size 3000000
cutoff: 1500000 10 times Time:1426ms with the size 3000000
cutoff: 1800000 10 times Time:1998ms with the size 3000000
cutoff: 2100000 10 times Time:1994ms with the size 3000000
cutoff: 2400000 10 times Time:1994ms with the size 3000000
cutoff: 2700000 10 times Time:1996ms with the size 3000000
cutoff: 3000000 10 times Time:2000ms with the size 3000000
Degree of parallelism: 16
```

For Array size 3000000: Thread 16 to Thread 64.

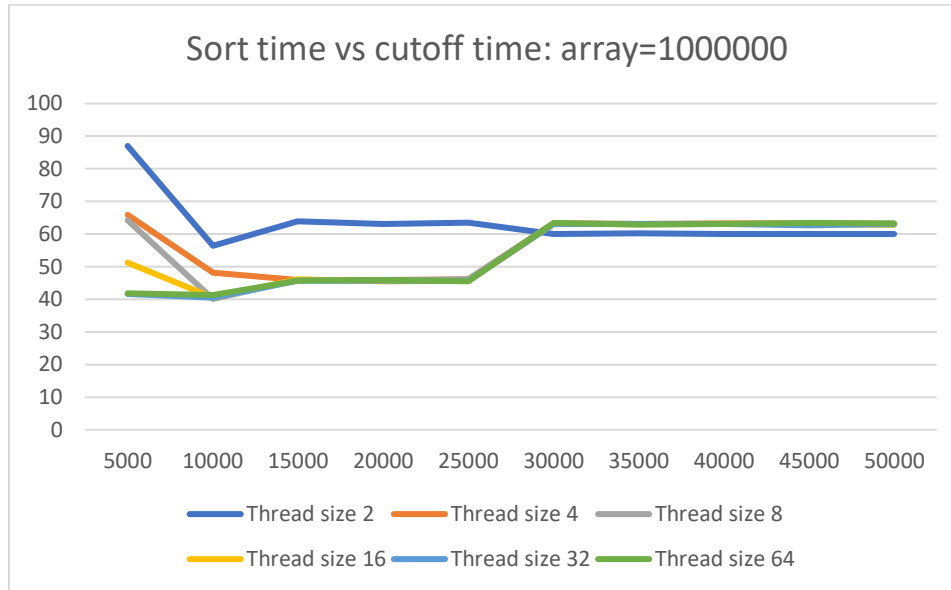
Program Structure and Algorithms
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```
Degree of parallelism: 16
cutoff: 300000      10 times Time:1426ms with the size 3000000
cutoff: 600000      10 times Time:1213ms with the size 3000000
cutoff: 900000      10 times Time:1430ms with the size 3000000
cutoff: 1200000     10 times Time:1424ms with the size 3000000
cutoff: 1500000     10 times Time:1428ms with the size 3000000
cutoff: 1800000     10 times Time:2002ms with the size 3000000
cutoff: 2100000     10 times Time:2004ms with the size 3000000
cutoff: 2400000     10 times Time:1990ms with the size 3000000
cutoff: 2700000     10 times Time:1993ms with the size 3000000
cutoff: 3000000     10 times Time:2000ms with the size 3000000
Degree of parallelism: 32
cutoff: 300000      10 times Time:1269ms with the size 3000000
cutoff: 600000      10 times Time:1214ms with the size 3000000
cutoff: 900000      10 times Time:1425ms with the size 3000000
cutoff: 1200000     10 times Time:1429ms with the size 3000000
cutoff: 1500000     10 times Time:1430ms with the size 3000000
cutoff: 1800000     10 times Time:1999ms with the size 3000000
cutoff: 2100000     10 times Time:2001ms with the size 3000000
cutoff: 2400000     10 times Time:1993ms with the size 3000000
cutoff: 2700000     10 times Time:1991ms with the size 3000000
cutoff: 3000000     10 times Time:2002ms with the size 3000000
Degree of parallelism: 64
cutoff: 300000      10 times Time:1265ms with the size 3000000
cutoff: 600000      10 times Time:1219ms with the size 3000000
cutoff: 900000      10 times Time:1429ms with the size 3000000
cutoff: 1200000     10 times Time:1429ms with the size 3000000
cutoff: 1500000     10 times Time:1427ms with the size 3000000
cutoff: 1800000     10 times Time:2001ms with the size 3000000
cutoff: 2100000     10 times Time:1986ms with the size 3000000
cutoff: 2400000     10 times Time:2001ms with the size 3000000
cutoff: 2700000     10 times Time:1995ms with the size 3000000
cutoff: 3000000     10 times Time:1996ms with the size 3000000
```

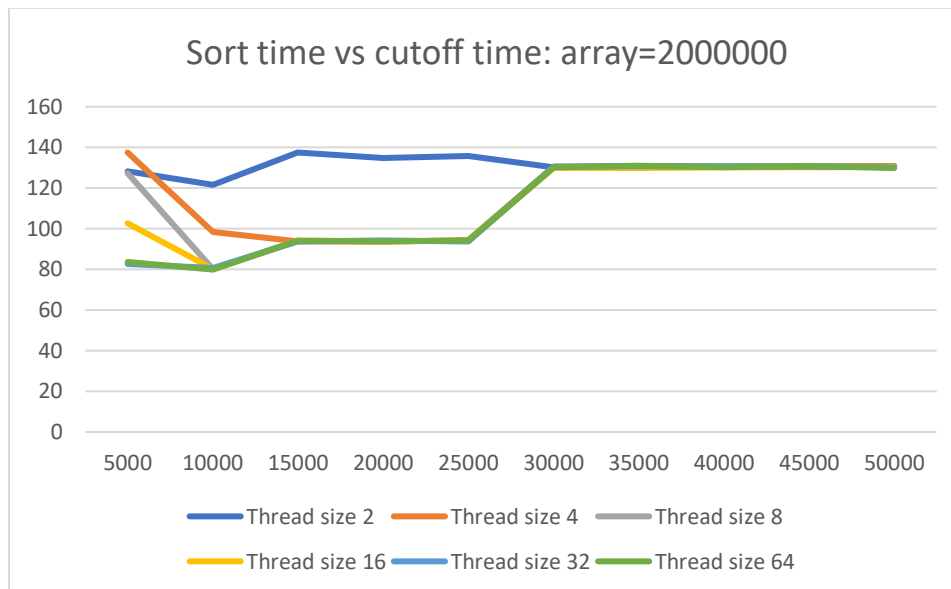
Graphs generated for the relation between Sort time and cutoff Time generated:

Array size 1000000:

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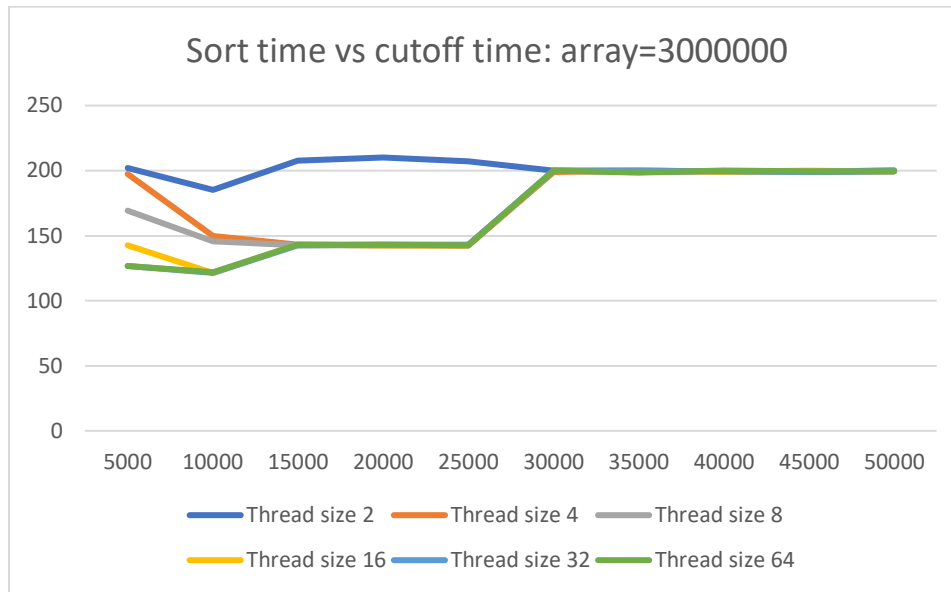


Array size 2000000:

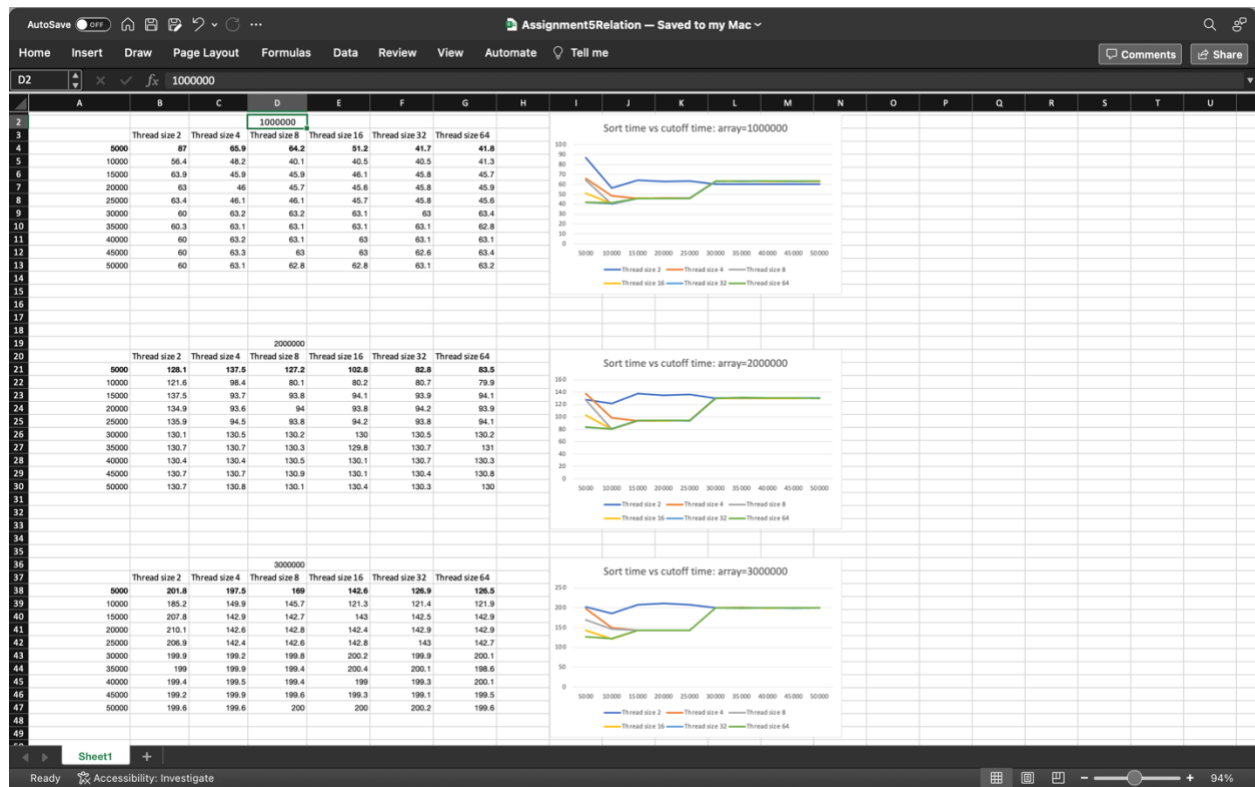


Array size 3000000:

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Screenshot for the table created for better understanding:



Github Repo URL: <https://github.com/rishdeore44/INFO6205.git>

Conclusion:

Tried to run different simulations to prove our experiment that too along with various combination as asked in the requirement, sized varied were cutoff, thread and the size of the array. After running the series of the experiment one thing is obvious that threads with instantiation 8 could be the ideal choice than the other instantiation of threads where other instantiation wouldn't show as much of an improvement in our experiment.

As we could see in the values noted, as the threads size increased, we get the ideal values for sort. But it is also noted thread 8 will give optimum result even if we keep on doing this sort with threads of size 64, the timings observed are almost similar to values obtained from thread 8.

1. The lowest runtime is achieved when the cutoff value is 25% of the array size.

$$\text{max_depth} = \log_2(t)$$

Any depth more significant than the max_depth is not feasible as the partitioned arrays hit the cutoff and turned into a system sort. However, in the given scenario, the **maximum depth is limited by the number of available threads rather than the size of the array being sorted.**

As long as the recursion depth does not exceed the maximum depth (i.e., $\log_2(t)$), the sorting algorithm can run successfully with the given number of threads. If the recursion depth exceeds the maximum depth, the partitioned arrays will be sorted using a System sort instead of a parallel one, which can result in slower performance.

Eclipse output from console:

Size of Array: 1000000

Degree of parallelism: 2

cutoff : 100000	10 times Time:870ms with the size 1000000
cutoff : 200000	10 times Time:564ms with the size 1000000
cutoff : 300000	10 times Time:639ms with the size 1000000
cutoff : 400000	10 times Time:630ms with the size 1000000
cutoff : 500000	10 times Time:634ms with the size 1000000
cutoff : 600000	10 times Time:600ms with the size 1000000
cutoff : 700000	10 times Time:603ms with the size 1000000
cutoff : 800000	10 times Time:600ms with the size 1000000
cutoff : 900000	10 times Time:600ms with the size 1000000
cutoff : 1000000	10 times Time:600ms with the size 1000000

Degree of parallelism: 4

cutoff : 100000	10 times Time:659ms with the size 1000000
cutoff : 200000	10 times Time:482ms with the size 1000000
cutoff : 300000	10 times Time:459ms with the size 1000000
cutoff : 400000	10 times Time:460ms with the size 1000000
cutoff : 500000	10 times Time:461ms with the size 1000000
cutoff : 600000	10 times Time:632ms with the size 1000000
cutoff : 700000	10 times Time:631ms with the size 1000000
cutoff : 800000	10 times Time:632ms with the size 1000000
cutoff : 900000	10 times Time:633ms with the size 1000000
cutoff : 1000000	10 times Time:631ms with the size 1000000

Degree of parallelism: 8

cutoff : 100000	10 times Time:642ms with the size 1000000
cutoff : 200000	10 times Time:401ms with the size 1000000
cutoff : 300000	10 times Time:459ms with the size 1000000
cutoff : 400000	10 times Time:457ms with the size 1000000
cutoff : 500000	10 times Time:461ms with the size 1000000
cutoff : 600000	10 times Time:632ms with the size 1000000
cutoff : 700000	10 times Time:631ms with the size 1000000
cutoff : 800000	10 times Time:631ms with the size 1000000
cutoff : 900000	10 times Time:630ms with the size 1000000
cutoff : 1000000	10 times Time:628ms with the size 1000000

Degree of parallelism: 16

cutoff : 100000	10 times Time:512ms with the size 1000000
cutoff : 200000	10 times Time:405ms with the size 1000000
cutoff : 300000	10 times Time:461ms with the size 1000000
cutoff : 400000	10 times Time:456ms with the size 1000000
cutoff : 500000	10 times Time:457ms with the size 1000000
cutoff : 600000	10 times Time:631ms with the size 1000000
cutoff : 700000	10 times Time:631ms with the size 1000000
cutoff : 800000	10 times Time:630ms with the size 1000000
cutoff : 900000	10 times Time:630ms with the size 1000000
cutoff : 1000000	10 times Time:628ms with the size 1000000

Degree of parallelism: 32

cutoff : 100000	10 times Time:417ms with the size 1000000
cutoff : 200000	10 times Time:405ms with the size 1000000
cutoff : 300000	10 times Time:458ms with the size 1000000
cutoff : 400000	10 times Time:458ms with the size 1000000
cutoff : 500000	10 times Time:458ms with the size 1000000
cutoff : 600000	10 times Time:630ms with the size 1000000
cutoff : 700000	10 times Time:631ms with the size 1000000
cutoff : 800000	10 times Time:631ms with the size 1000000
cutoff : 900000	10 times Time:626ms with the size 1000000
cutoff : 1000000	10 times Time:631ms with the size 1000000

Degree of parallelism: 64

cutoff : 100000	10 times Time:418ms with the size 1000000
cutoff : 200000	10 times Time:413ms with the size 1000000
cutoff : 300000	10 times Time:457ms with the size 1000000
cutoff : 400000	10 times Time:459ms with the size 1000000
cutoff : 500000	10 times Time:456ms with the size 1000000
cutoff : 600000	10 times Time:634ms with the size 1000000
cutoff : 700000	10 times Time:628ms with the size 1000000
cutoff : 800000	10 times Time:631ms with the size 1000000
cutoff : 900000	10 times Time:634ms with the size 1000000
cutoff : 1000000	10 times Time:632ms with the size 1000000

Size of Array: 2000000

Degree of parallelism: 2

cutoff : 200000	10 times Time:1281ms with the size 2000000
cutoff : 400000	10 times Time:1216ms with the size 2000000
cutoff : 600000	10 times Time:1375ms with the size 2000000
cutoff : 800000	10 times Time:1349ms with the size 2000000

cutoff : 1000000	10 times Time:1359ms with the size 2000000
cutoff : 1200000	10 times Time:1301ms with the size 2000000
cutoff : 1400000	10 times Time:1307ms with the size 2000000
cutoff : 1600000	10 times Time:1304ms with the size 2000000
cutoff : 1800000	10 times Time:1307ms with the size 2000000
cutoff : 2000000	10 times Time:1307ms with the size 2000000

Degree of parallelism: 4

cutoff : 200000	10 times Time:1375ms with the size 2000000
cutoff : 400000	10 times Time:984ms with the size 2000000
cutoff : 600000	10 times Time:937ms with the size 2000000
cutoff : 800000	10 times Time:936ms with the size 2000000
cutoff : 1000000	10 times Time:945ms with the size 2000000
cutoff : 1200000	10 times Time:1305ms with the size 2000000
cutoff : 1400000	10 times Time:1307ms with the size 2000000
cutoff : 1600000	10 times Time:1304ms with the size 2000000
cutoff : 1800000	10 times Time:1307ms with the size 2000000
cutoff : 2000000	10 times Time:1308ms with the size 2000000

Degree of parallelism: 8

cutoff : 200000	10 times Time:1272ms with the size 2000000
cutoff : 400000	10 times Time:801ms with the size 2000000
cutoff : 600000	10 times Time:938ms with the size 2000000
cutoff : 800000	10 times Time:940ms with the size 2000000
cutoff : 1000000	10 times Time:938ms with the size 2000000
cutoff : 1200000	10 times Time:1302ms with the size 2000000
cutoff : 1400000	10 times Time:1303ms with the size 2000000
cutoff : 1600000	10 times Time:1305ms with the size 2000000
cutoff : 1800000	10 times Time:1309ms with the size 2000000
cutoff : 2000000	10 times Time:1301ms with the size 2000000

Degree of parallelism: 16

cutoff : 200000	10 times Time:1028ms with the size 2000000
cutoff : 400000	10 times Time:802ms with the size 2000000
cutoff : 600000	10 times Time:941ms with the size 2000000
cutoff : 800000	10 times Time:938ms with the size 2000000
cutoff : 1000000	10 times Time:942ms with the size 2000000
cutoff : 1200000	10 times Time:1300ms with the size 2000000
cutoff : 1400000	10 times Time:1298ms with the size 2000000
cutoff : 1600000	10 times Time:1301ms with the size 2000000
cutoff : 1800000	10 times Time:1301ms with the size 2000000

cutoff : 2000000 10 times Time:1304ms with the size 2000000

Degree of parallelism: 32

cutoff : 200000 10 times Time:828ms with the size 2000000

cutoff : 400000 10 times Time:807ms with the size 2000000

cutoff : 600000 10 times Time:939ms with the size 2000000

cutoff : 800000 10 times Time:942ms with the size 2000000

cutoff : 1000000 10 times Time:938ms with the size 2000000

cutoff : 1200000 10 times Time:1305ms with the size 2000000

cutoff : 1400000 10 times Time:1307ms with the size 2000000

cutoff : 1600000 10 times Time:1307ms with the size 2000000

cutoff : 1800000 10 times Time:1304ms with the size 2000000

cutoff : 2000000 10 times Time:1303ms with the size 2000000

Degree of parallelism: 64

cutoff : 200000 10 times Time:835ms with the size 2000000

cutoff : 400000 10 times Time:799ms with the size 2000000

cutoff : 600000 10 times Time:941ms with the size 2000000

cutoff : 800000 10 times Time:939ms with the size 2000000

cutoff : 1000000 10 times Time:941ms with the size 2000000

cutoff : 1200000 10 times Time:1302ms with the size 2000000

cutoff : 1400000 10 times Time:1310ms with the size 2000000

cutoff : 1600000 10 times Time:1303ms with the size 2000000

cutoff : 1800000 10 times Time:1308ms with the size 2000000

cutoff : 2000000 10 times Time:1300ms with the size 2000000

Size of Array: 3000000

Degree of parallelism: 2

cutoff : 300000 10 times Time:2018ms with the size 3000000

cutoff : 600000 10 times Time:1852ms with the size 3000000

cutoff : 900000 10 times Time:2078ms with the size 3000000

cutoff : 1200000 10 times Time:2101ms with the size 3000000

cutoff : 1500000 10 times Time:2069ms with the size 3000000

cutoff : 1800000 10 times Time:1999ms with the size 3000000

cutoff : 2100000 10 times Time:1990ms with the size 3000000

cutoff : 2400000 10 times Time:1994ms with the size 3000000

cutoff : 2700000 10 times Time:1992ms with the size 3000000

cutoff : 3000000 10 times Time:1996ms with the size 3000000

Degree of parallelism: 4

cutoff : 300000 10 times Time:1975ms with the size 3000000

cutoff : 600000 10 times Time:1499ms with the size 3000000

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cutoff : 900000	10 times Time:1429ms with the size 3000000
cutoff : 1200000	10 times Time:1426ms with the size 3000000
cutoff : 1500000	10 times Time:1424ms with the size 3000000
cutoff : 1800000	10 times Time:1992ms with the size 3000000
cutoff : 2100000	10 times Time:1999ms with the size 3000000
cutoff : 2400000	10 times Time:1995ms with the size 3000000
cutoff : 2700000	10 times Time:1999ms with the size 3000000
cutoff : 3000000	10 times Time:1996ms with the size 3000000

Degree of parallelism: 8

cutoff : 300000	10 times Time:1690ms with the size 3000000
cutoff : 600000	10 times Time:1457ms with the size 3000000
cutoff : 900000	10 times Time:1427ms with the size 3000000
cutoff : 1200000	10 times Time:1428ms with the size 3000000
cutoff : 1500000	10 times Time:1426ms with the size 3000000
cutoff : 1800000	10 times Time:1998ms with the size 3000000
cutoff : 2100000	10 times Time:1994ms with the size 3000000
cutoff : 2400000	10 times Time:1994ms with the size 3000000
cutoff : 2700000	10 times Time:1996ms with the size 3000000
cutoff : 3000000	10 times Time:2000ms with the size 3000000

Degree of parallelism: 16

cutoff : 300000	10 times Time:1426ms with the size 3000000
cutoff : 600000	10 times Time:1213ms with the size 3000000
cutoff : 900000	10 times Time:1430ms with the size 3000000
cutoff : 1200000	10 times Time:1424ms with the size 3000000
cutoff : 1500000	10 times Time:1428ms with the size 3000000
cutoff : 1800000	10 times Time:2002ms with the size 3000000
cutoff : 2100000	10 times Time:2004ms with the size 3000000
cutoff : 2400000	10 times Time:1990ms with the size 3000000
cutoff : 2700000	10 times Time:1993ms with the size 3000000
cutoff : 3000000	10 times Time:2000ms with the size 3000000

Degree of parallelism: 32

cutoff : 300000	10 times Time:1269ms with the size 3000000
cutoff : 600000	10 times Time:1214ms with the size 3000000
cutoff : 900000	10 times Time:1425ms with the size 3000000
cutoff : 1200000	10 times Time:1429ms with the size 3000000
cutoff : 1500000	10 times Time:1430ms with the size 3000000
cutoff : 1800000	10 times Time:1999ms with the size 3000000
cutoff : 2100000	10 times Time:2001ms with the size 3000000

cutoff : 2400000	10 times Time:1993ms with the size 3000000
cutoff : 2700000	10 times Time:1991ms with the size 3000000
cutoff : 3000000	10 times Time:2002ms with the size 3000000
Degree of parallelism: 64	
cutoff : 300000	10 times Time:1265ms with the size 3000000
cutoff : 600000	10 times Time:1219ms with the size 3000000
cutoff : 900000	10 times Time:1429ms with the size 3000000
cutoff : 1200000	10 times Time:1429ms with the size 3000000
cutoff : 1500000	10 times Time:1427ms with the size 3000000
cutoff : 1800000	10 times Time:2001ms with the size 3000000
cutoff : 2100000	10 times Time:1986ms with the size 3000000
cutoff : 2400000	10 times Time:2001ms with the size 3000000
cutoff : 2700000	10 times Time:1995ms with the size 3000000
cutoff : 3000000	10 times Time:1996ms with the size 3000000