Xiaoran Li (NUID: 001023070)

INFO 6205

Program Structures & Algorithms Fall 2020

Assignment No.5

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.

A cutoff (defaults to, say, 1000) which you will update according to the first argument in the command line when running. It's your job to experiment and come up with a good value for this cutoff. If there are fewer elements to sort than the cutoff, then you should use the system sort instead.

Recursion depth or the number of available threads. Using this determination, you might decide on an ideal number (t) of separate threads (stick to powers of 2) and arrange for that number of partitions to be parallelized (by preventing recursion after the depth of lg t is reached).

An appropriate combination of these.

There is a Main class and the ParSort class in the sort.par package of the INFO6205 repository. The Main class can be used as is but the ParSort class needs to be implemented where you see "TODO..."

Unless you have a good reason not to, you should just go along with the Java8style future implementations provided for you in the class repository. Assignment Parallel Sort.pdf You must prepare a report that shows the results of your experiments and draws a conclusion (or more) about the efficacy of this method of parallelizing sort. Your experiments should involve sorting arrays of sufficient size for the parallel sort to make a difference. You should run with many different array sizes (they must be sufficiently large to make parallel sorting worthwhile, obviously) and different cutoff schemes.

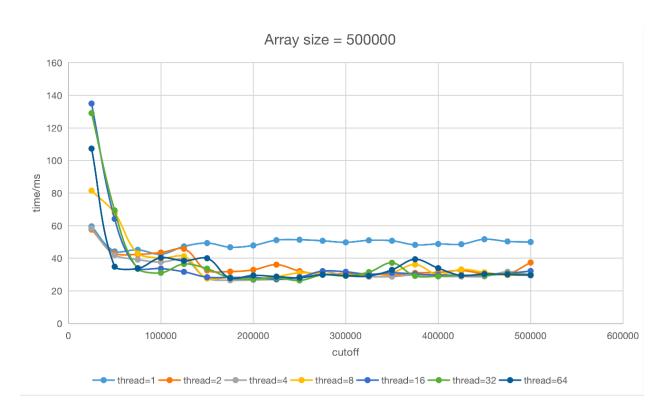
• **Output** (few outputs to prove relationship)

cutoff	1 thread	2 thread	4 thread	8 thread	16 thread	32 thread	64 thread	cutoff	1 thread	2 thread	4 thread	8 thread	16 thread	32 thread	64 thread
25000		57.6	58.35	81.55	135	129.1	107.35	50000	96.7	95.7	93.65	125.4	170.25	160.05	131.55
50000	44.25		42	67.8	64.2	69.4	34.85	100000	92.45	82.4	77.65	106.25	97.55		61.35
75000	45.2	42.4	39.2	43	34	33.55	33.75	150000	94.7	83.25	77.9	86.65	62.8	56.6	54.7
100000	42.5	43.55	37.7	40.15	33.7	31.1	40.35	200000	90.8	83	81.4	85.8	58.6	54.3	56.6
125000			39.35	41.25	31.7	36.5	38.5	250000	91.8	86	77.8	83.45	59.05	57.65	57.95
150000	49.35	32.5	27.65	27.65	28.4	33.65	40.05	300000	100.1	69.35	58.95	60.5	60.3	56.9	60.8
175000	46.8	31.85	26.5	28.3	28.25	28	27.8	350000	96.3	65.8	59.15	60.4	62.3	61.55	57.65
200000	47.9	32.9	26.7	27.7	28.25	27.25	29.5	400000	98.05	71.5	56.75	58.05	58	58.95	59.45
225000	51.15	36.1	27	28.75	27.2	28.05	28.75	450000	95.3	68.55	55.15	61.2	56.85	59.5	58.9
250000	51.4	32.15	27.65	31.1	28.45	26.4	28.05	500000	101.5	65.45	58	59.1	61.3	57.45	58.55
275000	50.75	30.1	31.95	30.45	32.15	29.8	30	550000	103.25	65.35	60.5	61.8	67.6	64.3	60.7
300000	49.8	30.65	29.25	29.85	31.7	29.25	29.35	600000	102.45	68	59.05	61.25	65.55	61	63.15
325000	51.05	30.45	28.7	29.95	30.2	31.5	29.2	650000	102.85	63.35	61.35	66.1	62.2	60.3	63.65
350000	50.75	29.75	28.75	31.25	31.1	37.25	32.9	700000	102.45	61.85	58.85	61.35	61.85	60.45	65.8
375000	48.25	31.05	29.8	36.2	30.35	29.2	39.4	750000	103.35	61.45	64.6	62.25	66.5	64.9	63.25
400000	48.8	31.35	28.9	30	29.75	28.95	33.95	800000	102.6	65.3	61.75	61.85	61.55	60.05	82.85
425000	48.65	32.5	28.8	33.15	29.55	29.6	29.45	850000	101.6	63.25	59	66.4	61.8	59.95	78.85
450000	51.7	30.55	28.9	31.4	29.45	29.55	30.4	900000	101.95	64.5	58.95	61.5	64.05	60.9	89.45
475000	50.35	30.45	31.75	29.65	30.7	30.45	30.1	950000	105.15	86.05	63.15	61.75	67.6	75	77.8
500000	= 0	27.4													
500000	50	37.4	30.05	29.8	32.2	29.8	29.6	1000000	101.25	62.5	59.3	61.65	63	62.5	80.55
cutoff	1 thread		4 thread		32.2 16 thread									62.5 32 thread	
	1 thread	2 thread													
cutoff	1 thread	2 thread	4 thread	8 thread	16 thread	32 thread	64 thread	cutoff	1 thread	2 thread	4 thread	8 thread	16 thread	32 thread	64 thread
cutoff 100000	1 thread 203 175.95	2 thread 200.1	4 thread 171.4	8 thread 204.6	16 thread 307.8	32 thread 245.85	64 thread 277.65	cutoff 200000	1 thread 453.65	2 thread 373.2	4 thread 375.3	8 thread 408.55	16 thread 471.7	32 thread 499.6 307.25	64 thread 329.4
cutoff 100000 200000	1 thread 203 175.95	2 thread 200.1 172.4 176.05	4 thread 171.4 155.75	8 thread 204.6 209.65	16 thread 307.8 160.45	32 thread 245.85 204.6	64 thread 277.65 163.15	cutoff 200000 400000	1 thread 453.65 327.9	2 thread 373.2 333.65	4 thread 375.3 317.9	8 thread 408.55 373.45	16 thread 471.7 368.85	32 thread 499.6 307.25	64 thread 329.4 242.5
cutoff 100000 200000 300000	1 thread 203 175.95 184.9	2 thread 200.1 172.4 176.05	4 thread 171.4 155.75 156.6	8 thread 204.6 209.65 143.9	16 thread 307.8 160.45 111.75	32 thread 245.85 204.6 115.1	64 thread 277.65 163.15 131.75	200000 400000 600000	1 thread 453.65 327.9 358.2	2 thread 373.2 333.65 349.4	4 thread 375.3 317.9 330.6	8 thread 408.55 373.45 294.7	16 thread 471.7 368.85 256	32 thread 499.6 307.25 256.75	329.4 242.5 241.85
cutoff 100000 200000 300000 400000	1 thread 203 175.95 184.9 178.8	2 thread 200.1 172.4 176.05 245	4 thread 171.4 155.75 156.6 153.05	8 thread 204.6 209.65 143.9 154.75	16 thread 307.8 160.45 111.75 107.95	32 thread 245.85 204.6 115.1 115.55	64 thread 277.65 163.15 131.75 137.3	200000 400000 600000 800000	1 thread 453.65 327.9 358.2 364.5	2 thread 373.2 333.65 349.4 352.15	4 thread 375.3 317.9 330.6 333.3	8 thread 408.55 373.45 294.7 294.05	16 thread 471.7 368.85 256 241.45	32 thread 499.6 307.25 256.75 238.3 241.5	329.4 242.5 241.85 247.2
200000 200000 300000 400000 500000	1 thread 203 175.95 184.9 178.8 207.45	2 thread 200.1 172.4 176.05 245 214.55	4 thread 171.4 155.75 156.6 153.05 154.95	8 thread 204.6 209.65 143.9 154.75 149.95	16 thread 307.8 160.45 111.75 107.95 108.7	32 thread 245.85 204.6 115.1 115.55 118.55	64 thread 277.65 163.15 131.75 137.3 135.15	200000 400000 600000 800000 1000000	1 thread 453.65 327.9 358.2 364.5 399.6	2 thread 373.2 333.65 349.4 352.15 344.75	4 thread 375.3 317.9 330.6 333.3 327.95	8 thread 408.55 373.45 294.7 294.05 310.85	16 thread 471.7 368.85 256 241.45 258.7	32 thread 499.6 307.25 256.75 238.3 241.5 261.05	64 thread 329.4 242.5 241.85 247.2 241.1
cutoff 100000 200000 300000 400000 500000	1 thread 203 175.95 184.9 178.8 207.45 229.95	2 thread 200.1 172.4 176.05 245 214.55 179.15	4 thread 171.4 155.75 156.6 153.05 154.95 103.9	8 thread 204.6 209.65 143.9 154.75 149.95 105.25	16 thread 307.8 160.45 111.75 107.95 108.7 102.65	32 thread 245.85 204.6 115.1 115.55 118.55 106.2	64 thread 277.65 163.15 131.75 137.3 135.15 142.2	200000 400000 600000 800000 1000000	1 thread 453.65 327.9 358.2 364.5 399.6 406.8	2 thread 373.2 333.65 349.4 352.15 344.75 270.15	4 thread 375.3 317.9 330.6 333.3 327.95 244.1	8 thread 408.55 373.45 294.7 294.05 310.85 239.75	16 thread 471.7 368.85 256 241.45 258.7 265.2	32 thread 499.6 307.25 256.75 238.3 241.5 261.05	64 thread 329.4 242.5 241.85 247.2 241.1 254.25
cutoff 100000 200000 300000 400000 500000 6000000 7000000	1 thread 203 175.95 184.9 178.8 207.45 229.95 185.45 191.55	2 thread 200.1 172.4 176.05 245 214.55 179.15	4 thread 171.4 155.75 156.6 153.05 154.95 103.9 105.25	8 thread 204.6 209.65 143.9 154.75 149.95 105.25 106.6	16 thread 307.8 160.45 111.75 107.95 108.7 102.65 106.75	32 thread 245.85 204.6 115.1 115.55 118.55 106.2 112.15	64 thread 277.65 163.15 131.75 137.3 135.15 142.2 125.95	200000 400000 600000 800000 1000000 1200000 1400000	1 thread 453.65 327.9 358.2 364.5 399.6 406.8 388.85	2 thread 373.2 333.65 349.4 352.15 344.75 270.15 394.05	4 thread 375.3 317.9 330.6 333.3 327.95 244.1 242.05	8 thread 408.55 373.45 294.7 294.05 310.85 239.75 239.2	16 thread 471.7 368.85 256 241.45 258.7 265.2 253.55	32 thread 499.6 307.25 256.75 238.3 241.5 261.05 258.4 253.45	64 thread 329.4 242.5 241.85 247.2 241.1 254.25 251.75
cutoff 100000 200000 300000 400000 500000 6000000 7000000 8000000	1 thread 203 175.95 184.9 178.8 207.45 229.95 185.45 191.55	2 thread 200.1 172.4 176.05 245 214.55 179.15 151.2 145.7	4 thread 171.4 155.75 156.6 153.05 154.95 103.9 105.25 105.9	8 thread 204.6 209.65 143.9 154.75 149.95 105.25 106.6 108.7	16 thread 307.8 160.45 111.75 107.95 108.7 102.65 106.75 105.35	32 thread 245.85 204.6 115.1 115.55 118.55 106.2 112.15 109.35	64 thread 277.65 163.15 131.75 137.3 135.15 142.2 125.95 115.45	200000 400000 600000 800000 1000000 1200000 1400000	1 thread 453.65 327.9 358.2 364.5 399.6 406.8 388.85 391.6	2 thread 373.2 333.65 349.4 352.15 344.75 270.15 394.05 310.5	4 thread 375.3 317.9 330.6 333.3 327.95 244.1 242.05 234.8	8 thread 408.55 373.45 294.7 294.05 310.85 239.75 239.2 240.25	16 thread 471.7 368.85 256 241.45 258.7 265.2 253.55 265.25	32 thread 499.6 307.25 256.75 238.3 241.5 261.05 258.4 253.45	64 thread 329.4 242.5 241.85 247.2 241.1 254.25 251.75 267.25
cutoff 100000 200000 300000 400000 500000 600000 700000 800000	1 thread 203 175.95 184.9 178.8 207.45 229.95 185.45 191.55 189.35	2 thread 200.1 172.4 176.05 245 214.55 179.15 151.2 145.7 148.5 137.15	4 thread 171.4 155.75 156.6 153.05 154.95 103.9 105.25 105.9 105.2	8 thread 204.6 209.65 143.9 154.75 149.95 105.25 106.6 108.7 106.85	16 thread 307.8 160.45 111.75 107.95 108.7 102.65 106.75 105.35 105.95	32 thread 245.85 204.6 115.1 115.55 118.55 106.2 112.15 109.35	64 thread 277.65 163.15 131.75 137.3 135.15 142.2 125.95 115.45 110.35	200000 400000 600000 800000 1000000 1200000 1400000 1800000	1 thread 453.65 327.9 358.2 364.5 399.6 406.8 388.85 391.6 409.6	2 thread 373.2 333.65 349.4 352.15 344.75 270.15 394.05 310.5 280.45	4 thread 375.3 317.9 330.6 333.3 327.95 244.1 242.05 234.8 235.35	8 thread 408.55 373.45 294.75 294.05 310.85 239.75 239.2 240.25 241.35	16 thread 471.7 368.85 256 241.45 258.7 265.2 253.55 265.25 243.65	32 thread 499.6 307.25 256.75 238.3 241.5 261.05 258.4 253.45 254.1 267.5	64 thread 329.4 242.5 241.85 247.2 241.1 254.25 251.75 267.25 247.4
cutoff 100000 200000 300000 400000 500000 600000 700000 800000 900000 10000000	1 thread 203 175.95 184.9 178.8 207.45 229.95 185.45 191.55 189.35	2 thread 200.1 172.4 176.05 245 214.55 179.15 151.2 145.7 148.5 137.15	4 thread 171.4 155.75 156.6 153.05 154.95 105.25 105.9 105.2 105.2 102.4	8 thread 204.6 209.65 143.9 154.75 149.95 105.25 106.6 108.7 106.85 107.55	16 thread 307.8 160.45 111.75 107.95 108.7 102.65 106.75 105.35 105.95 106.2	32 thread 245.85 204.6 115.1 115.55 118.55 106.2 112.15 109.35 109.4	64 thread 277.65 163.15 131.75 137.3 135.15 142.2 125.95 115.45 110.35 111.65	200000 400000 600000 800000 1000000 1200000 1400000 1800000 20000000	1 thread 453.65 327.9 358.2 364.5 399.6 406.8 388.85 391.6 409.6 408.55	2 thread 373.2 333.65 349.4 352.15 344.75 270.15 394.05 310.5 280.45 284.5	4 thread 375.3 317.9 330.6 333.3 327.95 244.1 242.05 234.8 235.35 245.75	8 thread 408.55 373.45 294.75 210.85 239.75 239.2 240.25 241.35 239.75	16 thread 471.7 368.85 256 241.45 258.7 265.2 253.55 265.25 243.65 268.15	32 thread 499.6 307.25 256.75 238.3 241.5 261.05 258.4 253.45 254.1 267.5	64 thread 329.4 242.5 241.85 247.2 241.1 254.25 251.75 267.25 247.4 255.95
cutoff 100000 200000 300000 400000 500000 600000 700000 800000 900000 11000000	1 thread 203 175.95 184.9 178.8 207.45 229.95 185.45 191.55 189.35 190.1	2 thread 200.1 172.4 176.05 245 214.55 179.15 151.2 145.7 148.5 137.15 129.5	4 thread 171.4 155.75 156.6 153.05 154.95 103.9 105.25 105.9 105.2 102.4 115.8	8 thread 204.6 209.65 143.9 154.75 149.95 105.25 106.6 108.7 106.85 107.55	16 thread 307.8 160.45 111.75 107.95 108.7 102.65 106.75 105.35 105.95 106.2 117.9	32 thread 245.85 204.6 115.1 115.55 118.55 106.2 112.15 109.35 109.4 109.45 121.75	64 thread 277.65 163.15 131.75 137.3 135.15 142.2 125.95 115.45 110.35 111.65 124.6	200000 400000 600000 800000 1000000 1200000 1400000 1800000 2000000 22000000	1 thread 453.65 327.9 358.2 364.5 399.6 406.8 388.85 391.6 409.6 408.55	2 thread 373.2 333.65 349.4 352.15 344.75 270.15 394.05 310.5 280.45 284.5	4 thread 375.3 317.9 330.6 333.3 327.95 244.1 242.05 234.8 235.35 245.75 248.4	8 thread 408.55 373.45 294.7 294.05 310.85 239.75 240.25 241.35 239.75 253.15	16 thread 471.7 368.85 256 241.45 258.7 265.2 253.55 265.25 243.65 268.15 253.15	32 thread 499.6 307.25 256.75 238.3 241.5 261.05 258.4 253.45 267.5 273.1	64 thread 329.4 242.5 241.85 247.2 241.1 254.25 251.75 267.25 247.4 255.95 264.35
cutoff 100000 200000 300000 400000 500000 600000 700000 800000 1000000 11000000 12000000	1 thread 203 175,95 184.9 178.8 207.45 229.95 185.45 191.55 189.35 190.1 193.3	2 thread 200.1 172.4 176.05 245 214.55 179.15 151.2 145.7 148.5 137.15 129.5	4 thread 171.4 155.75 156.6 153.05 154.95 103.9 105.25 105.9 105.2 102.4 115.8	8 thread 204.6 209.65 143.9 154.75 149.95 105.25 106.6 108.7 106.85 107.55 121.3	16 thread 307.8 160.45 111.75 107.95 108.7 102.65 106.75 105.35 105.95 106.2 117.9 117.35	32 thread 245.85 204.6 115.1 115.55 118.55 106.2 112.15 109.35 109.4 109.45 121.75 123	64 thread 277.65 163.15 131.75 137.3 135.15 142.2 125.95 115.45 110.35 111.65 124.6	200000 400000 800000 1000000 1200000 1400000 1800000 2000000 24000000	1 thread 453.65 327.9 358.2 364.5 399.6 406.8 388.85 391.6 409.6 408.55 402 403.8	2 thread 373.2 333.65 349.4 352.15 344.75 270.15 394.05 310.5 280.45 284.5 314.3 329.8	4 thread 375.3 317.9 330.6 333.3 327.95 244.1 242.05 234.8 235.35 245.75 248.4 252.25	8 thread 408.55 373.45 294.75 294.05 310.85 239.75 240.25 241.35 239.75 253.15 252.25	16 thread 471.7 368.85 256 241.45 258.7 265.2 253.55 265.25 243.65 268.15 253.15 261.85	32 thread 499.6 307.25 256.75 238.3 241.5 261.05 258.4 253.45 267.5 273.1 275.45 270.25	64 thread 329.4 242.5 241.85 247.2 241.1 254.25 251.75 267.25 247.4 255.95 264.35 272.85
cutoff 100000 200000 300000 400000 500000 600000 700000 800000 1000000 11000000 12000000 13000000	1 thread 203 175,95 184,9 178.8 207.45 229.95 185.45 191.55 189.35 190.1 193.3 193.6 192.9	2 thread 200.1 172.4 176.05 245 214.55 179.15 151.2 145.7 148.5 137.15 129.5 128.45 140.6	4 thread 171.4 155.75 156.6 153.05 154.95 103.9 105.25 105.9 105.2 102.4 115.8 115.85 118.1	8 thread 204.6 209.65 143.9 154.75 149.95 105.25 106.6 108.7 106.85 107.55 121.3 123.65	16 thread 307.8 160.45 111.75 107.95 108.7 102.65 106.75 105.35 105.95 106.2 117.9 117.35 118.05	32 thread 245.85 204.6 115.1 115.55 118.55 106.2 112.15 109.35 109.4 109.45 121.75 123 121.65	64 thread 277.65 163.15 131.75 137.3 135.15 142.2 125.95 115.45 110.35 124.6 124.9 124.5	200000 400000 800000 1000000 1200000 1400000 1600000 2000000 2400000 26000000	1 thread 453.65 327.9 358.2 364.5 399.6 406.8 388.85 391.6 409.6 408.55 402 403.8 401.85	2 thread 373.2 333.65 349.4 352.15 344.75 270.15 394.05 310.5 280.45 284.5 314.3 329.8 324.85	4 thread 375.3 317.9 330.6 333.3 327.95 244.1 242.05 234.8 235.35 245.75 248.4 252.25 253.05	8 thread 408.55 373.45 294.75 294.05 310.85 239.75 240.25 241.35 239.75 252.25 249.8	16 thread 471.7 368.85 256 241.45 258.7 265.2 253.55 265.25 243.65 268.15 253.15 261.85	32 thread 499.6 307.25 256.75 238.3 241.5 261.05 258.4 253.45 267.5 273.1 275.45 270.25 271.15	64 thread 329.4 242.5 241.85 247.2 241.1 254.25 251.75 267.25 247.4 255.95 264.35 272.85 271.65
cutoff 100000 200000 300000 400000 500000 600000 700000 800000 1000000 11000000 12000000 13000000 14000000	1 thread 203 175,95 184,9 178.8 207.45 229.95 185.45 191.55 189.35 190.1 193.3 193.6 192.9	2 thread 200.1 172.4 176.05 245 214.55 179.15 151.2 145.7 148.5 137.15 129.5 128.45 140.6 145.7	4 thread 171.4 155.75 156.6 153.05 154.95 103.9 105.25 105.9 105.2 115.8 115.85 118.1 115.9	8 thread 204.6 209.65 143.9 154.75 149.95 105.25 106.6 108.7 106.85 121.3 123.65 121.15 121.1 121.3	16 thread 307.8 160.45 111.75 107.95 108.7 102.65 106.75 105.35 105.95 106.2 117.9 117.35 118.05 117.3	32 thread 245.85 204.6 115.1 115.55 118.55 106.2 112.15 109.35 109.4 109.45 121.75 123 121.65 119.25	64 thread 277.65 163.15 131.75 137.3 135.15 142.2 125.95 115.45 110.35 124.6 124.9 124.5 125.25	200000 400000 800000 1000000 1200000 1400000 1800000 2000000 2400000 2600000 2800000	1 thread 453.65 327.9 358.2 364.5 399.6 406.8 388.85 391.6 409.6 408.55 402 403.8 401.85 424.65	2 thread 373.2 333.65 349.4 352.15 344.75 270.15 394.05 310.5 280.45 284.5 314.3 329.8 324.85 329.05	4 thread 375.3 317.9 330.6 333.3 327.95 244.1 242.05 234.8 235.35 245.75 248.4 252.25 253.05 249.7	8 thread 408.55 373.45 294.75 294.05 310.85 239.75 240.25 241.35 239.75 253.15 252.25 249.8 251.6	16 thread 471.7 368.85 256 241.45 258.7 265.2 253.55 265.25 243.65 268.15 253.15 261.85 251.9 249.3	32 thread 499.6 307.25 256.75 238.3 241.5 261.05 258.4 253.45 267.5 273.1 275.45 270.25 271.15	64 thread 329.4 242.5 241.85 247.2 241.1 254.25 251.75 267.25 247.4 255.95 264.35 272.85 271.65 265.75
cutoff 100000 200000 300000 400000 500000 600000 700000 800000 1000000 11000000 1200000 1300000 1400000 1500000	1 thread 203 175.95 184.9 178.8 207.45 229.95 185.45 191.55 190.1 193.3 193.6 192.9 193.25 193.6	2 thread 200.1 172.4 176.05 245 214.55 179.15 151.2 145.7 148.5 137.15 129.5 128.45 140.6 145.7 134.1	4 thread 171.4 155.75 156.6 153.05 154.95 103.9 105.25 105.9 105.2 115.8 115.85 118.1 115.9 116	8 thread 204.6 209.65 143.9 154.75 149.95 105.25 106.6 108.7 106.85 121.3 123.65 121.15 121.1	16 thread 307.8 160.45 111.75 107.95 108.7 102.65 106.75 105.35 105.95 106.2 117.9 117.35 118.05 117.3	32 thread 245.85 204.6 115.1 115.55 118.55 106.2 112.15 109.35 109.4 109.45 121.75 123 121.65 119.25 121.7	64 thread 277.65 163.15 131.75 137.3 135.15 142.2 125.95 115.45 110.35 124.6 124.9 124.5 125.25 124.4	200000 400000 800000 1000000 1200000 1400000 1800000 2200000 2400000 2800000 30000000	1 thread 453.65 327.9 358.2 364.5 399.6 406.8 388.85 391.6 409.6 408.55 402 403.8 401.85 424.65 416.9	2 thread 373.2 333.65 349.4 352.15 344.75 270.15 394.05 310.5 280.45 284.5 314.3 329.8 324.85 329.05 286.6	4 thread 375.3 317.9 330.6 333.3 327.95 244.1 242.05 234.8 235.35 245.75 248.4 252.25 253.05 249.7 253.35	8 thread 408.55 373.45 294.75 294.05 310.85 239.75 240.25 241.35 239.75 252.25 249.8 251.6 253.7	16 thread 471.7 368.85 256 241.45 258.7 265.2 253.55 265.25 243.65 268.15 253.15 261.85 251.9 249.3 251.55	32 thread 499.6 307.25 256.75 238.3 241.5 261.05 258.4 253.45 267.5 273.1 275.45 270.25 271.15	64 thread 329.4 242.5 241.85 247.2 241.1 254.25 251.75 267.25 247.4 255.95 264.35 272.85 271.65 265.75 265.5
cutoff 100000 200000 300000 400000 500000 600000 700000 800000 1000000 11000000 1200000 1400000 1500000 1600000	1 thread 203 175.95 184.9 178.8 207.45 229.95 185.45 191.55 189.35 190.1 193.3 193.6 192.9 193.25 193.6 192.4	2 thread 200.1 172.4 176.05 245 214.55 179.15 151.2 145.7 148.5 137.15 129.5 128.45 140.6 145.7 134.1	4 thread 171.4 155.75 156.6 153.05 154.95 103.9 105.25 105.9 105.2 115.8 115.85 118.1 115.9 116.7	8 thread 204.6 209.65 143.9 154.75 149.95 105.25 106.6 108.7 106.85 121.3 123.65 121.15 121.1 121.3	16 thread 307.8 160.45 111.75 107.95 108.7 102.65 106.75 105.35 105.95 106.2 117.9 117.35 118.05 117.3 118.2 117.25	32 thread 245.85 204.6 115.1 115.55 118.55 106.2 112.15 109.35 109.4 109.45 121.75 123 121.65 119.25 121.7	64 thread 277.65 163.15 131.75 137.3 135.15 142.2 125.95 115.45 110.35 124.6 124.9 124.5 125.25 124.4 124.35	200000 400000 800000 1000000 1200000 1400000 1800000 2000000 2400000 2800000 3000000 32000000	1 thread 453.65 327.9 358.2 364.5 399.6 406.8 388.85 391.6 409.6 408.55 402 403.8 401.85 424.65 416.9 433.15	2 thread 373.2 333.65 349.4 352.15 344.75 270.15 394.05 280.45 284.5 314.3 329.8 324.85 329.05 286.6 321.3	4 thread 375.3 317.9 330.6 333.3 327.95 244.1 242.05 234.8 235.35 245.75 248.4 252.25 253.05 249.7 253.35 252.55	8 thread 408.55 373.45 294.75 294.05 310.85 239.75 240.25 241.35 239.75 252.25 249.8 251.6 253.7 252.85	16 thread 471.7 368.85 256 241.45 258.7 265.2 253.55 265.25 243.65 253.15 261.85 251.9 249.3 251.55 259.9	32 thread 499.6 307.25 256.75 238.3 241.5 261.05 258.4 253.45 267.5 273.1 275.45 270.25 271.15 268.1	64 thread 329.4 242.5 241.85 247.2 241.1 254.25 251.75 267.25 247.4 255.95 264.35 271.65 265.75 264.7
200000 200000 300000 400000 500000 600000 700000 800000 1000000 11000000 1200000 1400000 1500000 1700000	1 thread 203 175.95 184.9 178.8 207.45 229.95 185.45 191.55 189.35 190.1 193.3 193.6 192.9 193.25 193.6 192.4 193 195.75	2 thread 200.1 172.4 176.05 245 214.55 179.15 151.2 145.7 148.5 137.15 129.5 140.6 145.7 134.1 136.9	4 thread 171.4 155.75 156.6 153.05 154.95 103.9 105.25 105.9 105.2 115.8 115.85 118.1 115.9 116.7 115.5	8 thread 204.6 209.65 143.9 154.75 149.95 105.25 106.6 108.7 106.85 121.3 123.65 121.15 121.1 121.3 122.8	16 thread 307.8 160.45 111.75 107.95 108.7 102.65 106.75 105.35 105.95 106.2 117.9 117.35 118.05 117.3 118.2 117.25 116.9	32 thread 245.85 204.6 115.1 115.55 118.55 106.2 112.15 109.35 109.4 109.45 121.75 123 121.65 119.25 121.7 118 118.25	64 thread 277.65 163.15 131.75 137.3 135.15 142.2 125.95 115.45 110.35 111.65 124.6 124.9 124.5 125.25 124.4 124.35 124.8	200000 400000 800000 1000000 1200000 1400000 1800000 2200000 2400000 2800000 3000000 3400000	1 thread 453.65 327.9 358.2 364.5 399.6 406.8 388.85 391.6 409.6 408.55 402 403.8 401.85 424.65 416.9 433.15 401.4	2 thread 373.2 333.65 349.4 352.15 344.75 270.15 394.05 280.45 284.5 314.3 329.8 324.85 329.05 286.6 321.3 299.15	4 thread 375.3 317.9 330.6 333.3 327.95 244.1 242.05 234.8 235.35 245.75 248.4 252.25 253.05 249.7 253.35 252.55 251.65	8 thread 408.55 373.45 294.75 294.05 310.85 239.75 240.25 241.35 239.75 252.25 249.8 251.6 253.7 252.85 257.35	16 thread 471.7 368.85 256 241.45 258.7 265.2 253.55 265.25 243.65 253.15 261.85 251.9 249.3 251.55 259.9 267.05	32 thread 499.6 307.25 256.75 238.3 241.5 261.05 258.4 253.45 267.5 273.1 275.45 270.25 271.15 271.1 268.1 270.6	64 thread 329.4 242.5 241.85 247.2 241.1 254.25 251.75 267.25 247.4 255.95 264.35 271.65 265.75 264.7 273.45

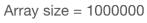
Relationship conclusion

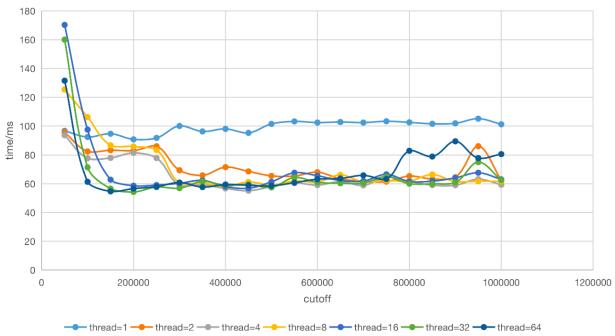
I changed both the number of thread and the number of cutoff in four different size of arrays. According to these outputs and graphs. I find these conclusions:

- 1. When the number of thread bigger than 4, there is nearly no benefit to keep increasing the number of thread. In the other words, 4 threads always have the better performance than 1 threads and 2 threads. But 8 threads, 16 threads and even more threads cost the same time withe 4 threads. Therefore, 4 threads is the best choice.
- 2. Look at the graph, it is obviously that when the value of cutoff is 30% of the size of arrays. The time decreases a lot. This situation is suitable for all four different size of arrays. So, the best value of cutoff should be 30% of the size of arrays.
- 3. According to 1 and 2, I think the best combination of thread and cutoff is that uses 4 threads and the value of cutoff is 30% of the size of arrays.
 - Evidence to support relationship (screen shot and/or graph and/or spreadsheet)

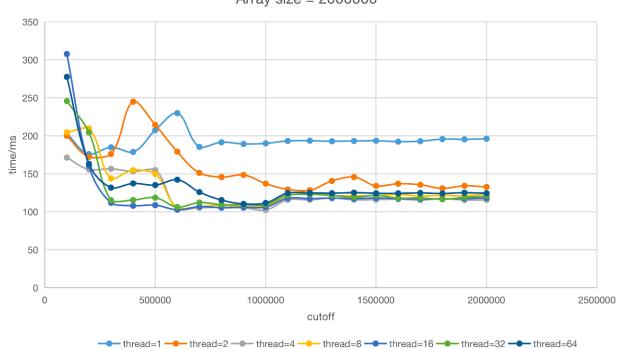


Xiaoran Li (NUID: 001023070)





Array size = 2000000



Xiaoran Li (NUID: 001023070)

