Problem1 Report

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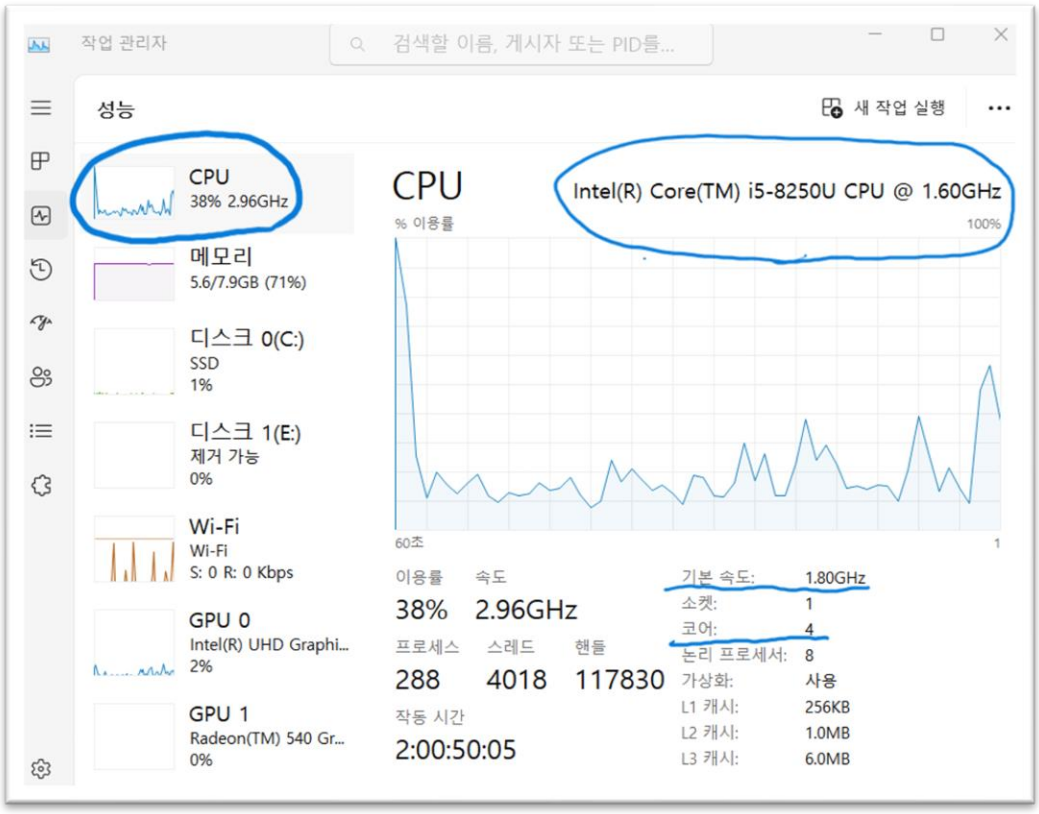
[Environment]

- **CPU**

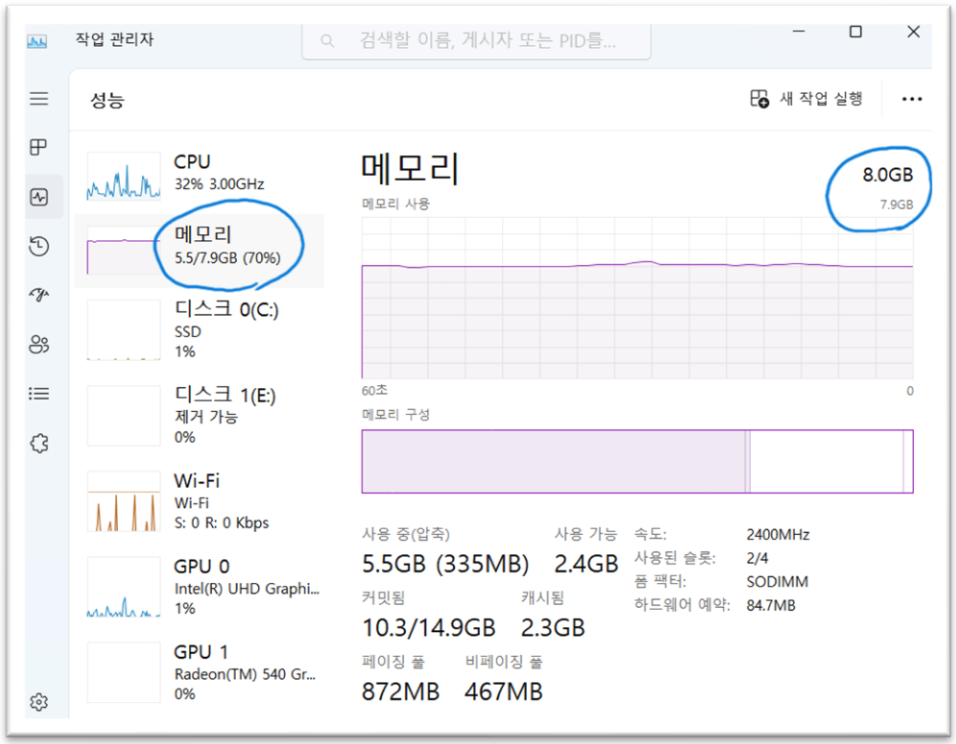


CPU type: Intel® Core™ i5-8250U CPU

Clock Speed: 1.80GHz

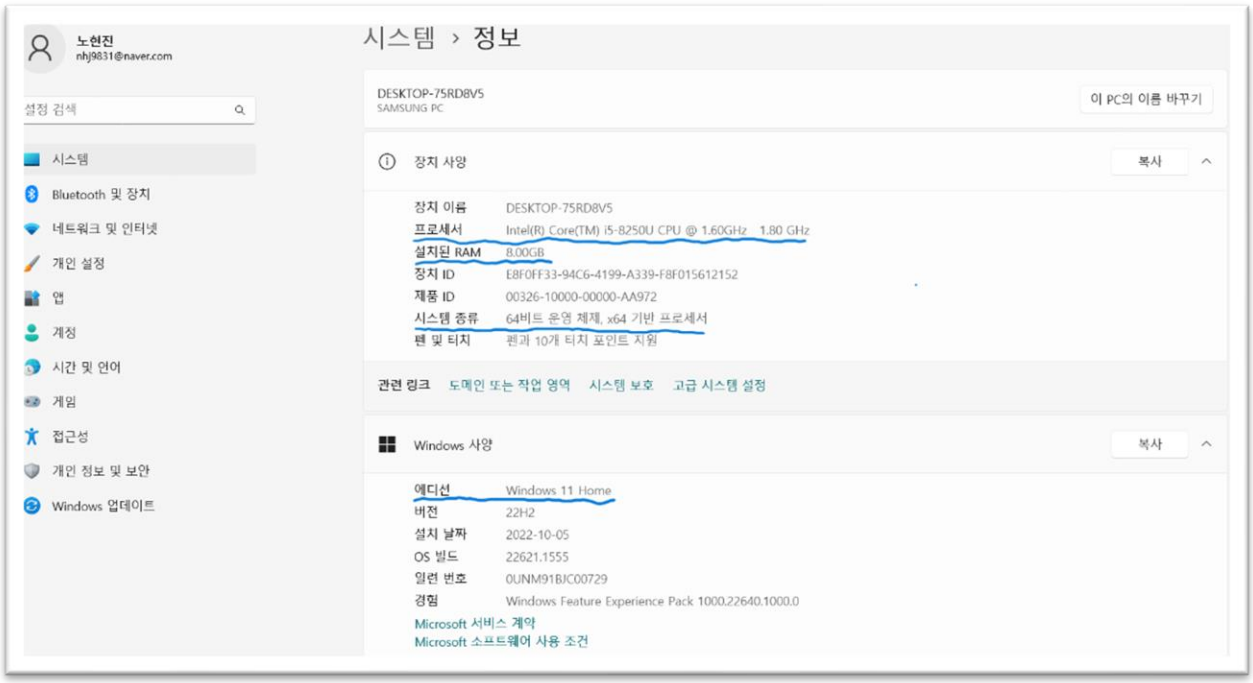
Number of cores: 4

- **Memory**



Memory size: 8.0GB

- **OS**



OS type: Windows 11

[Source Code]

- **pc_static_block.java**

```
package com.hyunjin.study.problem1;

/*
 This program should print the following values:
 (1) execution time of each thread
 (2) program execution time
 (3) the number of 'prime numbers'
*/

public final class pc_static_block {
    private static int NUM_THREADS = 1;  // default number of threads: 1
    private static int NUM_END = 200000; // default input: 200000

    public static void main(String[] args) {
        if (args.length == 2) {
            NUM_THREADS = Integer.parseInt(args[0]); // Possible number of
threads: 1, 2, 4, 6, 8, 10, 12, 14, 16, 32
            NUM_END = Integer.parseInt(args[1]);
        }

        BlockThread[] blockThreads = new BlockThread[NUM_THREADS];
        int[] results = new int[NUM_THREADS];

        int workUnit = NUM_END / NUM_THREADS;
        for (int i = 1; i <= NUM_THREADS; i++) {
            int startNum = workUnit * (i - 1) + 1;
            int endNum;
            if (i == NUM_THREADS) {
                endNum = NUM_END;
            } else {
                endNum = workUnit * i;
```

```
            }
            blockThreads[i - 1] = new BlockThread(startNum, endNum, results, i -
1);
        }

        long startTime = System.currentTimeMillis();

        for (BlockThread blockThread : blockThreads) {
            blockThread.start();
        }

        try {
            for (BlockThread blockThread : blockThreads) {
                blockThread.join();
            }
        } catch (Exception ignored) {}

        int answer = 0;
        for (int result : results) {
            answer += result;
        }

        long endTime = System.currentTimeMillis();
        long timeDiff = endTime - startTime;
        System.out.println("\nProgram Execution Time: " + timeDiff + "ms");
        System.out.println("1 ~ " + NUM_END + ", the number of 'prime numbers': "
+ answer);
    }
}

final class BlockThread extends Thread {
    private final int startNum;
    private final int endNum;
    private final int[] results;
    private final int index;

    public BlockThread(int startNum, int endNum, int[] results, int index) {
        this.startNum = startNum;
        this.endNum = endNum;
        this.results = results;
        this.index = index;
    }

    @Override
    public void run() {
        long startTime = System.currentTimeMillis();

        for (int i = startNum; i <= endNum; i++) {
            if (isPrime(i)) {
                results[index] += 1;
            }
        }

        long endTime = System.currentTimeMillis();
        long timeDiff = endTime - startTime;

        System.out.println(this.getName() + " ==> " + startNum + " ~ " + endNum +
", Execution Time: " + timeDiff + "ms");
    }

    private boolean isPrime(int x) {
        if (x <= 1) {
            return false;
        }
        for (int i = 2; i < x; i++) {
            if (x % i == 0) {
```

```
                return false;
            }
        }
        return true;
    }
}
```

- **pc_static_cyclic.java**

```
package com.hyunjin.study.problem1;

/*
 This program should print the following values:
 (1) execution time of each thread
 (2) program execution time
 (3) the number of 'prime numbers'
*/

public final class pc_static_cyclic {
    private static int NUM_THREADS = 1;  // default number of threads
    private static int NUM_END = 200000; // default input

    public static void main(String[] args) {
        if (args.length == 2) {
            NUM_THREADS = Integer.parseInt(args[0]); // Possible number of
threads: 1, 2, 4, 6, 8, 10, 12, 14, 16, 32
            NUM_END = Integer.parseInt(args[1]);
        }

        CyclicThread[] cyclicThreads = new CyclicThread[NUM_THREADS];
        int[] results = new int[NUM_THREADS];

        int workUnit = NUM_THREADS * 10;
        int endNum = NUM_END;
        for (int i = 1; i <= NUM_THREADS; i++) {
            int startNum = 10 * (i - 1) + 1;
            cyclicThreads[i - 1] = new CyclicThread(startNum, endNum, workUnit,
results, i - 1);
        }

        long startTime = System.currentTimeMillis();

        for (CyclicThread cyclicThread : cyclicThreads) {
            cyclicThread.start();
        }

        try {
            for (CyclicThread cyclicThread : cyclicThreads) {
                cyclicThread.join();
            }
        } catch (Exception ignored) {}

        int answer = 0;
        for (int result : results) {
            answer += result;
        }

        long endTime = System.currentTimeMillis();
        long timeDiff = endTime - startTime;
        System.out.println("\nProgram Execution Time: " + timeDiff + "ms");
        System.out.println("1 ~ " + NUM_END + ", the number of 'prime numbers': "
+ answer);
    }
}
```

```
final class CyclicThread extends Thread {
    private final int startNum;
    private final int endNum;
    private final int workUnit;
    private final int[] results;
    private final int index;

    public CyclicThread(int startNum, int endNum, int workUnit, int[] results, int
index) {
        this.startNum = startNum;
        this.endNum = endNum;
        this.workUnit = workUnit;
        this.results = results;
        this.index = index;
    }

    @Override
    public void run() {
        long startTime = System.currentTimeMillis();

        for (int i = startNum; i <= endNum; i += workUnit) {
            for (int j = 0; j < 10; j++) {
                if (isPrime(i + j)) {
                    results[index] += 1;
                }
            }
        }

        long endTime = System.currentTimeMillis();
        long timeDiff = endTime - startTime;
        System.out.println(this.getName() + " ==> Execution Time: " + timeDiff +
"ms");
    }

    private boolean isPrime(int x) {
        if (x <= 1) {
            return false;
        }
        for (int i = 2; i < x; i++) {
            if (x % i == 0) {
                return false;
            }
        }
        return true;
    }
}
```

- **pc_dynamic.java**

```
package com.hyunjin.study.problem1;

/*
 This program should print the following values:
 (1) execution time of each thread
 (2) program execution time
 (3) the number of 'prime numbers'
*/

public final class pc_dynamic {
    private static int NUM_THREADS = 1; // default number of threads
    private static int NUM_END = 200000; // default input
    private static int NUM_START = 1;

    public static void main(String[] args) {
```

```
        if (args.length == 2) {
            NUM_THREADS = Integer.parseInt(args[0]); // Possible number of
threads: 1, 2, 4, 6, 8, 10, 12, 14, 16, 32
            NUM_END = Integer.parseInt(args[1]);
        }
        DynamicThread[] dynamicThreads = new DynamicThread[NUM_THREADS];
        int[] results = new int[NUM_THREADS];

        for (int i = 1; i <= NUM_THREADS; i++) {
            dynamicThreads[i - 1] = new DynamicThread(results, i - 1);
        }

        long startTime = System.currentTimeMillis();

        for (DynamicThread dynamicThread : dynamicThreads) {
            dynamicThread.start();
        }

        try {
            for (DynamicThread dynamicThread : dynamicThreads) {
                dynamicThread.join();
            }
        } catch (Exception ignored) {}

        int answer = 0;
        for (int result : results) {
            answer += result;
        }

        long endTime = System.currentTimeMillis();
        long timeDiff = endTime - startTime;
        System.out.println("\nProgram Execution Time: " + timeDiff + "ms");
        System.out.println("1 ~ " + NUM_END + ", the number of 'prime numbers': "
+ answer);
    }

    public synchronized static int getWork() {
        if (NUM_START >= NUM_END) {
            return -1;
        } else {
            NUM_START += 10;
            return (NUM_START - 10);
        }
    }
}

final class DynamicThread extends Thread {
    private final int[] results;
    private final int index;

    public DynamicThread(int[] results, int index) {
        this.results = results;
        this.index = index;
    }

    @Override
    public void run() {
        long startTime = System.currentTimeMillis();

        while (true) {
            int startNum = pc_dynamic.getWork();
            if (startNum == -1) {
                break;
            }
            for (int i = startNum; i < startNum + 10; i++) {
                if (isPrime(i)) {
```

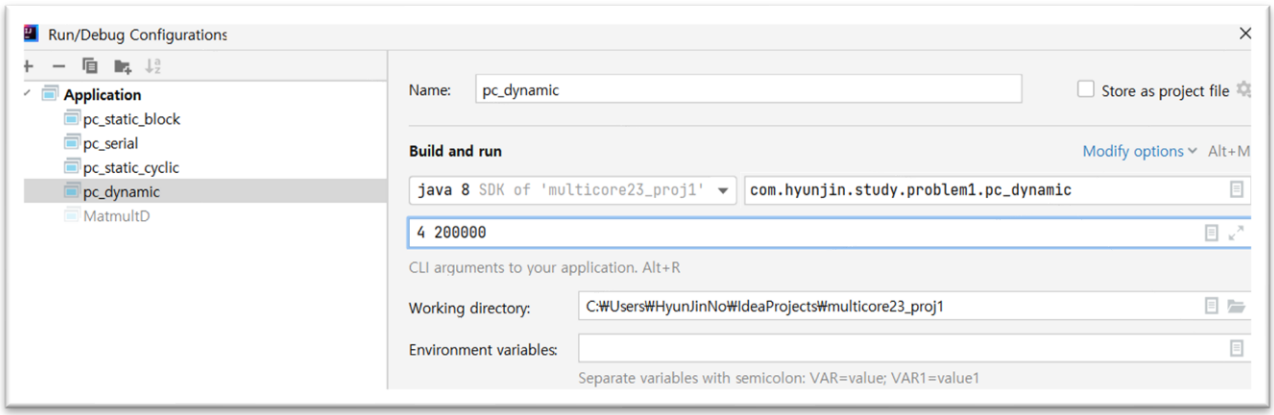
```
                    results[index] += 1;
                }
            }
        }

        long endTime = System.currentTimeMillis();
        long timeDiff = endTime - startTime;
        System.out.println(this.getName() + " ==> Execution Time: " + timeDiff +
"ms");
    }

    private boolean isPrime(int x) {
        if (x <= 1) {
            return false;
        }
        for (int i = 2; i < x; i++) {
            if (x % i == 0) {
                return false;
            }
        }
        return true;
    }
}
```

- **How to compile and execute**
  1. **Firstly, install Intellij IDEA.**
  2. **After installation, open the submitted file.**
  3. **Before execution, click "Edit Configurations.."**

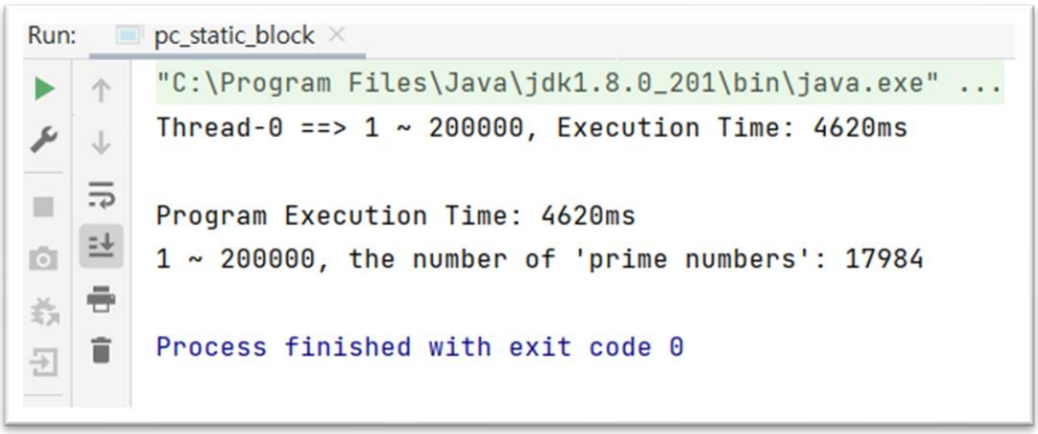
  4. **Set the arguments. In this picture, "4" means NUM_THREADS, and "200000" means NUM_END.**

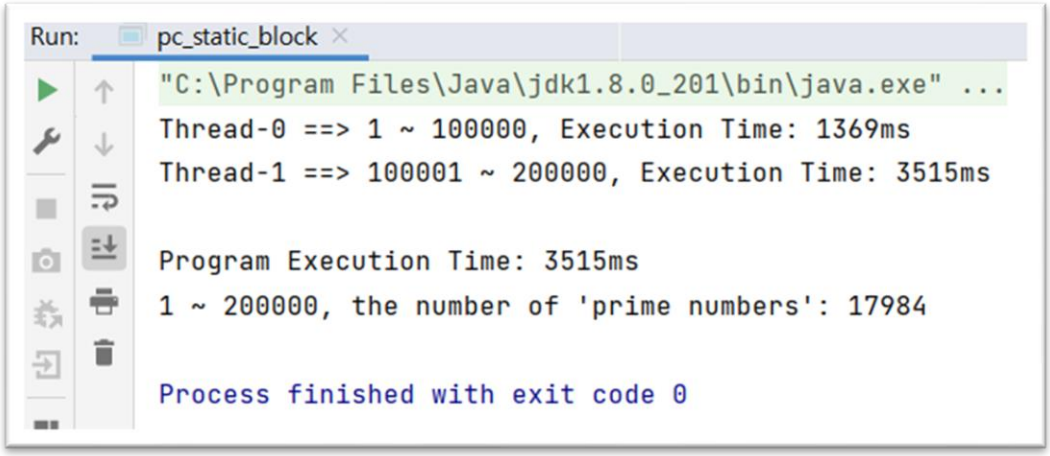


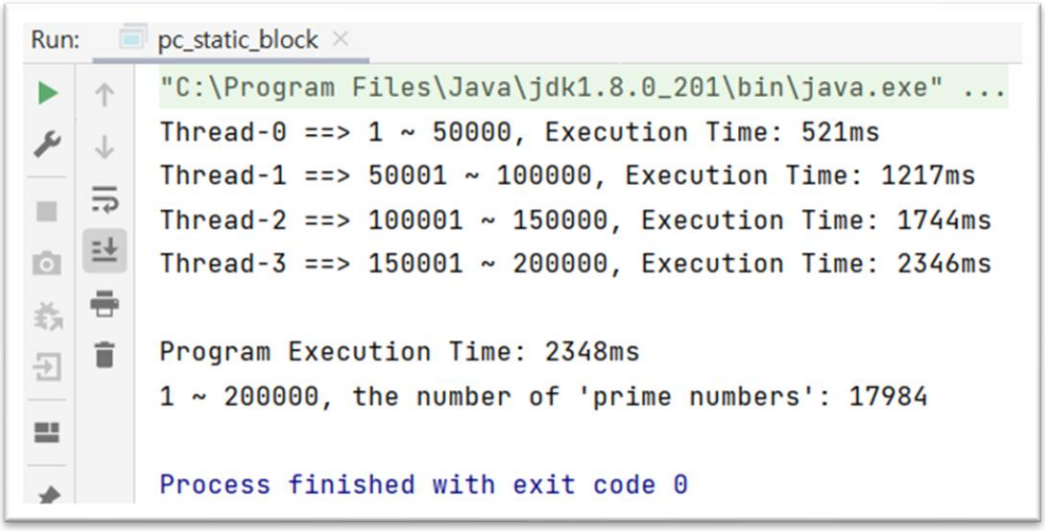
  5. **Finally, run the source code.**

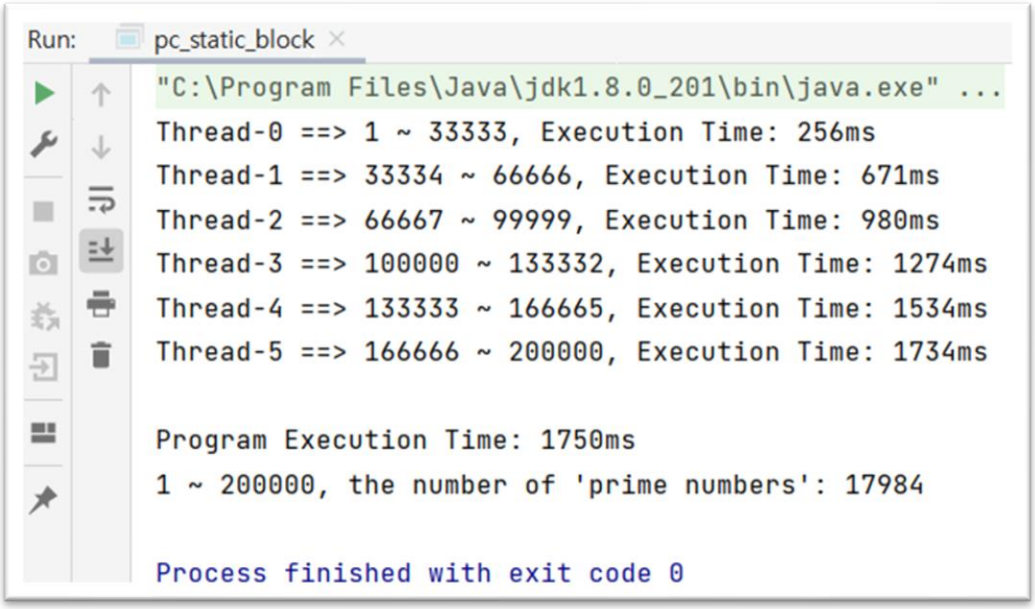
[Results]

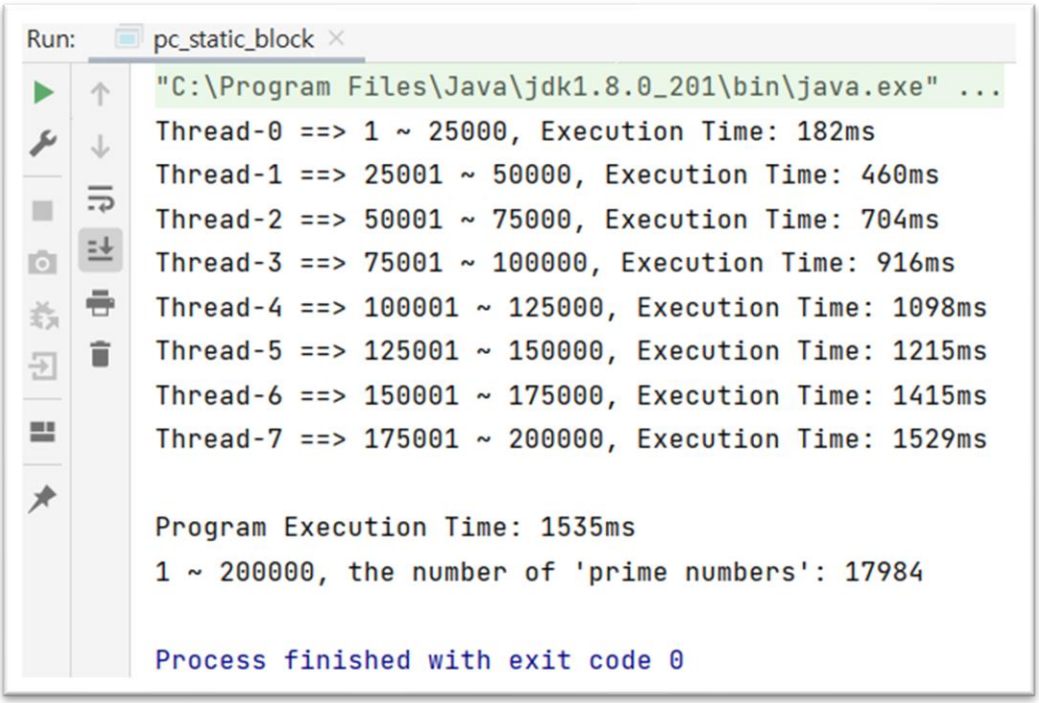
- **Static (Block)**

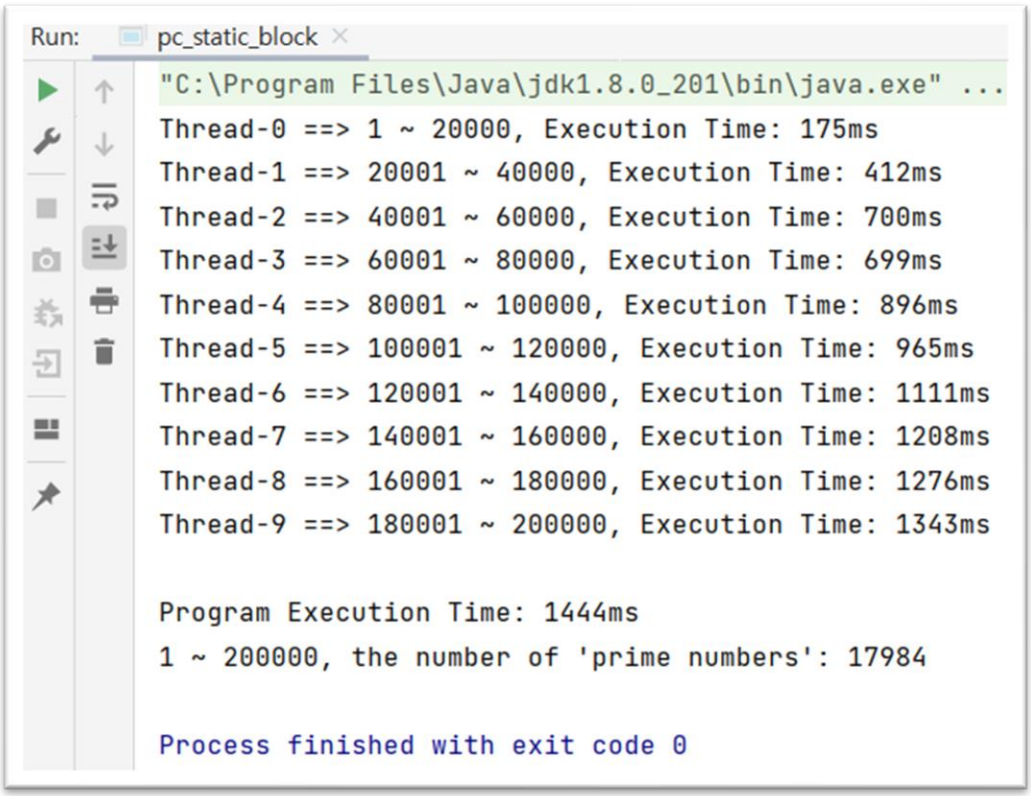


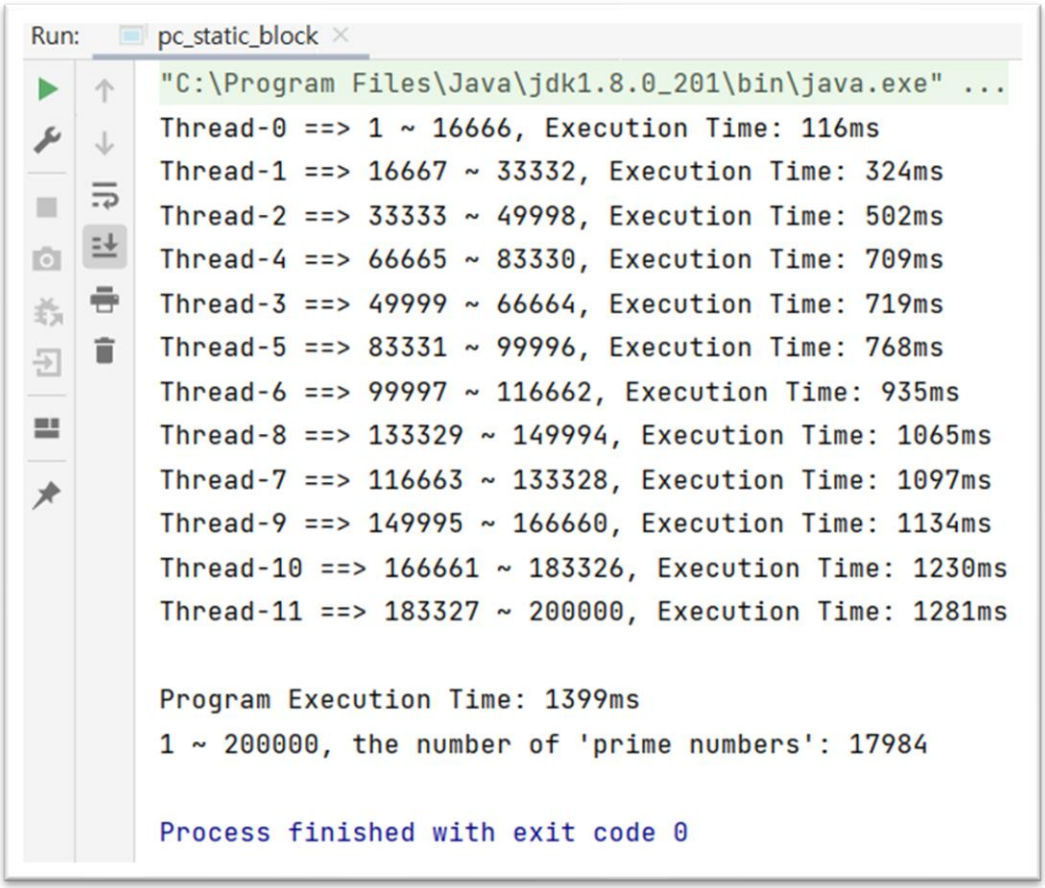


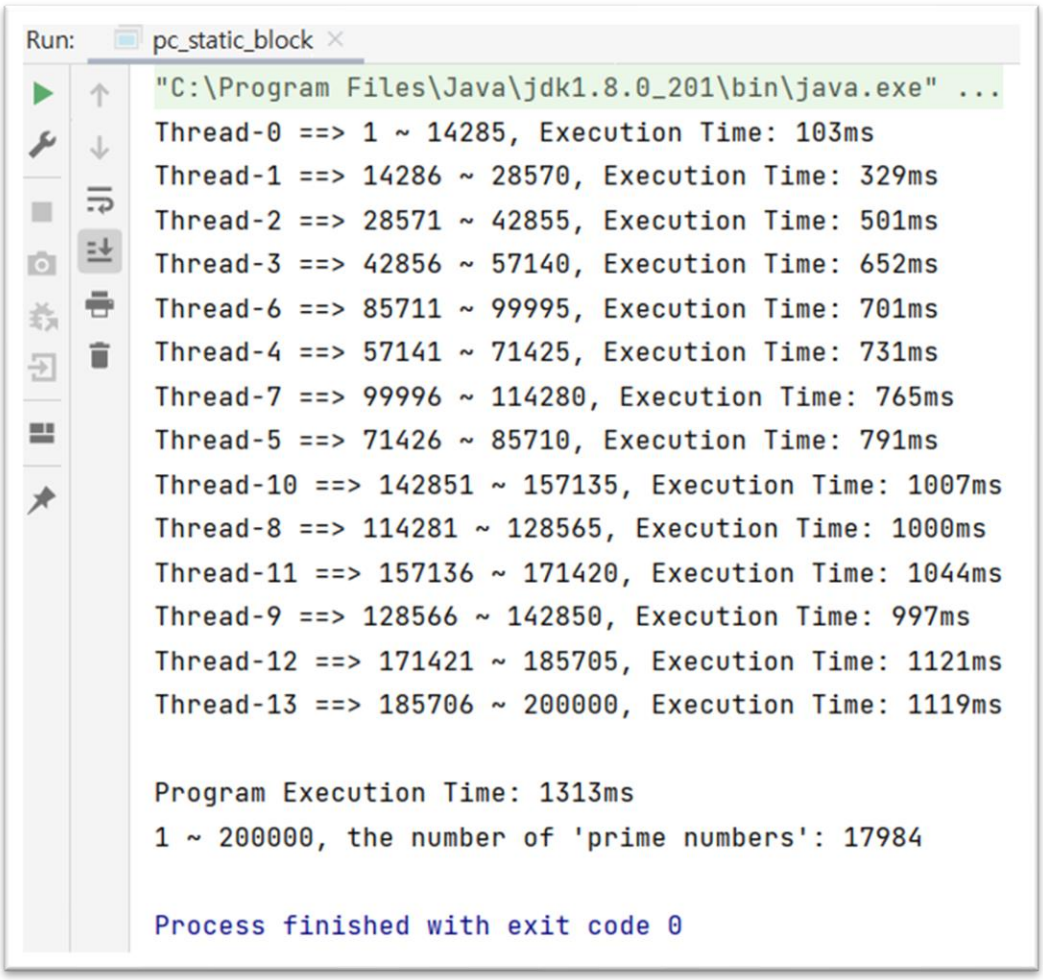


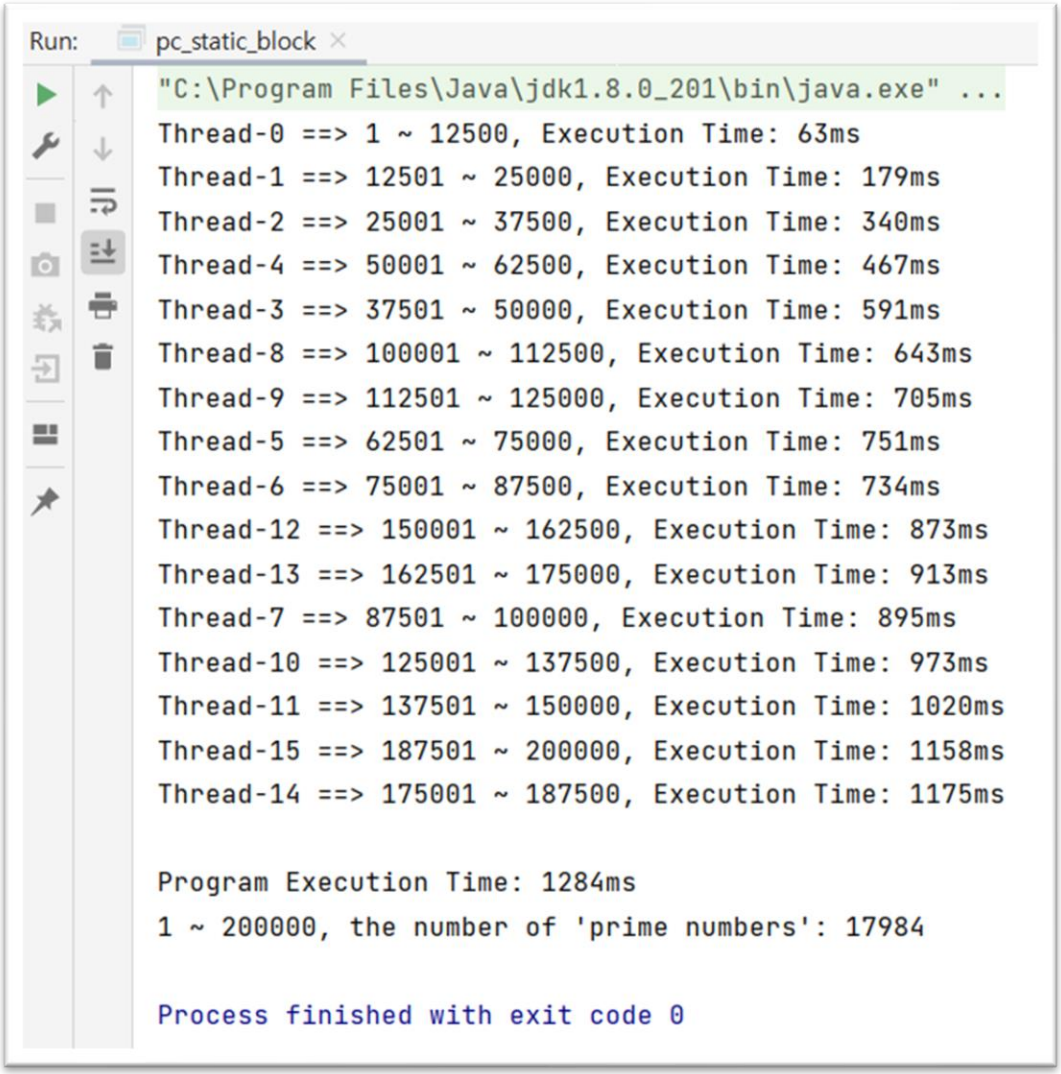

Run:
pc_static_block
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-0 ==> 1 ~ 33333, Execution Time: 256ms
Thread-1 ==> 33334 ~ 66666, Execution Time: 671ms
Thread-2 ==> 66667 ~ 99999, Execution Time: 980ms
Thread-3 ==> 100000 ~ 133332, Execution Time: 1274ms
Thread-4 ==> 133333 ~ 166665, Execution Time: 1534ms
Thread-5 ==> 166666 ~ 200000, Execution Time: 1734ms
Program Execution Time: 1750ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

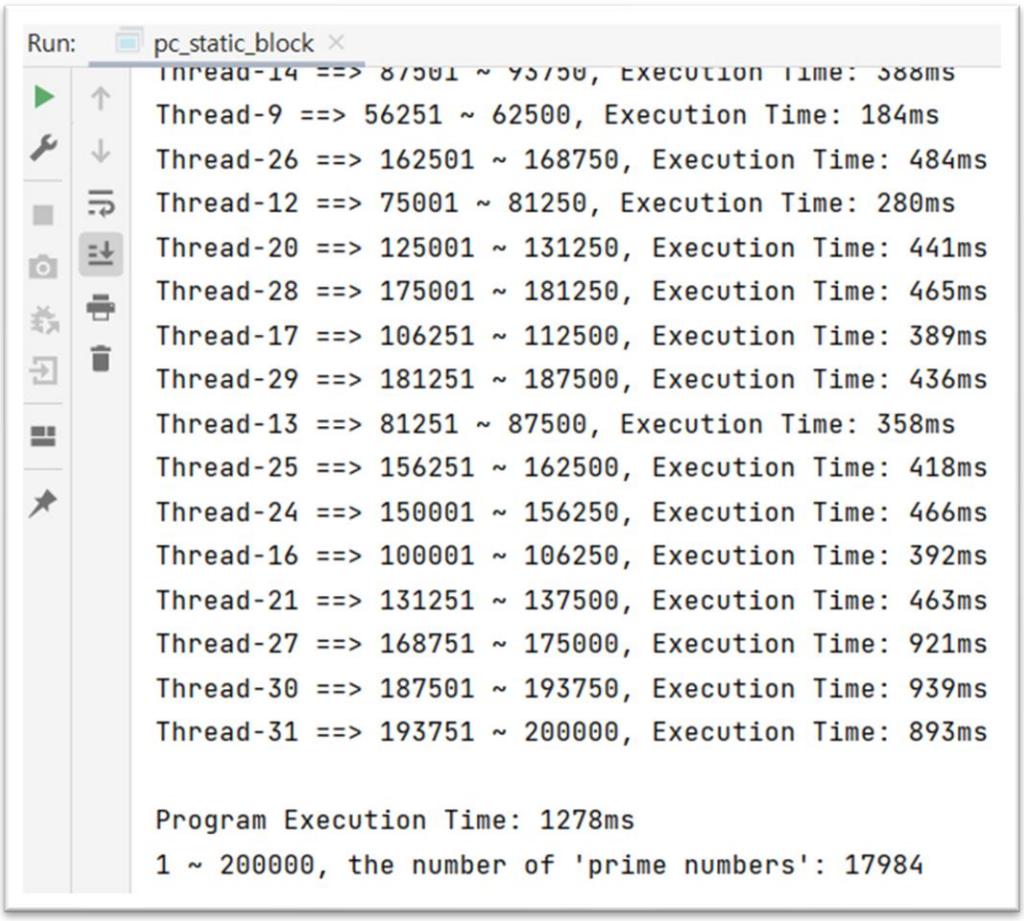

Run:
pc_static_block
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-0 ==> 1 ~ 25000, Execution Time: 182ms
Thread-1 ==> 25001 ~ 50000, Execution Time: 460ms
Thread-2 ==> 50001 ~ 75000, Execution Time: 704ms
Thread-3 ==> 75001 ~ 100000, Execution Time: 916ms
Thread-4 ==> 100001 ~ 125000, Execution Time: 1098ms
Thread-5 ==> 125001 ~ 150000, Execution Time: 1215ms
Thread-6 ==> 150001 ~ 175000, Execution Time: 1415ms
Thread-7 ==> 175001 ~ 200000, Execution Time: 1529ms
Program Execution Time: 1535ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0


Run:
pc_static_block
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-0 ==> 1 ~ 20000, Execution Time: 175ms
Thread-1 ==> 20001 ~ 40000, Execution Time: 412ms
Thread-2 ==> 40001 ~ 60000, Execution Time: 700ms
Thread-3 ==> 60001 ~ 80000, Execution Time: 699ms
Thread-4 ==> 80001 ~ 100000, Execution Time: 896ms
Thread-5 ==> 100001 ~ 120000, Execution Time: 965ms
Thread-6 ==> 120001 ~ 140000, Execution Time: 1111ms
Thread-7 ==> 140001 ~ 160000, Execution Time: 1208ms
Thread-8 ==> 160001 ~ 180000, Execution Time: 1276ms
Thread-9 ==> 180001 ~ 200000, Execution Time: 1343ms
Program Execution Time: 1444ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

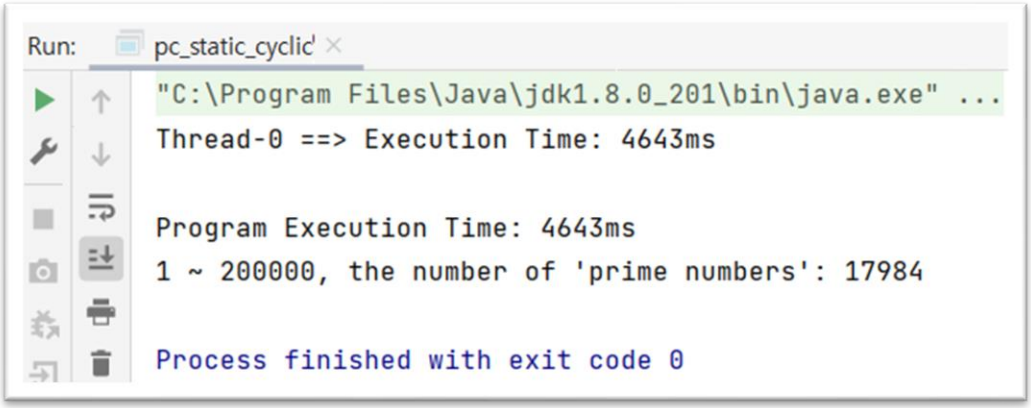

Run:
pc_static_block
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-0 ==> 1 ~ 16666, Execution Time: 116ms
Thread-1 ==> 16667 ~ 33332, Execution Time: 324ms
Thread-2 ==> 33333 ~ 49998, Execution Time: 502ms
Thread-4 ==> 66665 ~ 83330, Execution Time: 709ms
Thread-3 ==> 49999 ~ 66664, Execution Time: 719ms
Thread-5 ==> 83331 ~ 99996, Execution Time: 768ms
Thread-6 ==> 99997 ~ 116662, Execution Time: 935ms
Thread-8 ==> 133329 ~ 149994, Execution Time: 1065ms
Thread-7 ==> 116663 ~ 133328, Execution Time: 1097ms
Thread-9 ==> 149995 ~ 166660, Execution Time: 1134ms
Thread-10 ==> 166661 ~ 183326, Execution Time: 1230ms
Thread-11 ==> 183327 ~ 200000, Execution Time: 1281ms
Program Execution Time: 1399ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

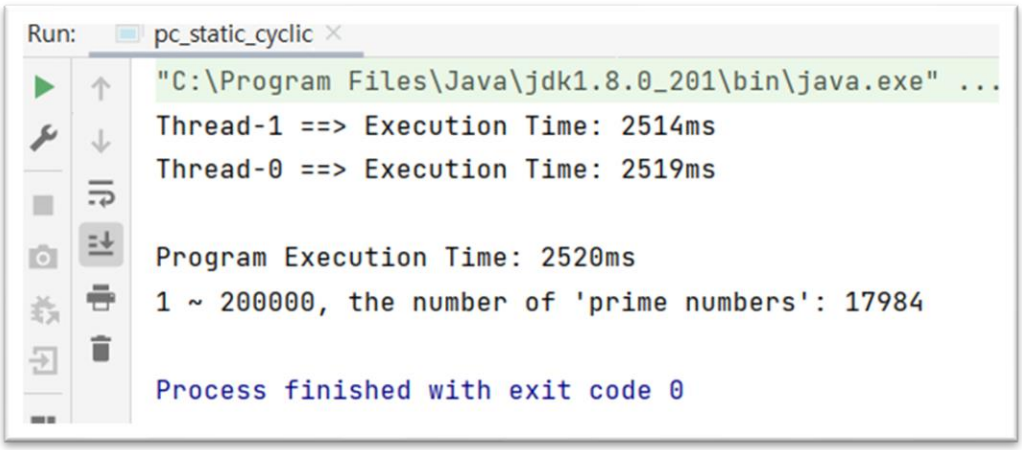

Run:
pc_static_block
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-0 ==> 1 ~ 14285, Execution Time: 103ms
Thread-1 ==> 14286 ~ 28570, Execution Time: 329ms
Thread-2 ==> 28571 ~ 42855, Execution Time: 501ms
Thread-3 ==> 42856 ~ 57140, Execution Time: 652ms
Thread-6 ==> 85711 ~ 99995, Execution Time: 701ms
Thread-4 ==> 57141 ~ 71425, Execution Time: 731ms
Thread-7 ==> 99996 ~ 114280, Execution Time: 765ms
Thread-5 ==> 71426 ~ 85710, Execution Time: 791ms
Thread-10 ==> 142851 ~ 157135, Execution Time: 1007ms
Thread-8 ==> 114281 ~ 128565, Execution Time: 1000ms
Thread-11 ==> 157136 ~ 171420, Execution Time: 1044ms
Thread-9 ==> 128566 ~ 142850, Execution Time: 997ms
Thread-12 ==> 171421 ~ 185705, Execution Time: 1121ms
Thread-13 ==> 185706 ~ 200000, Execution Time: 1119ms
Program Execution Time: 1313ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

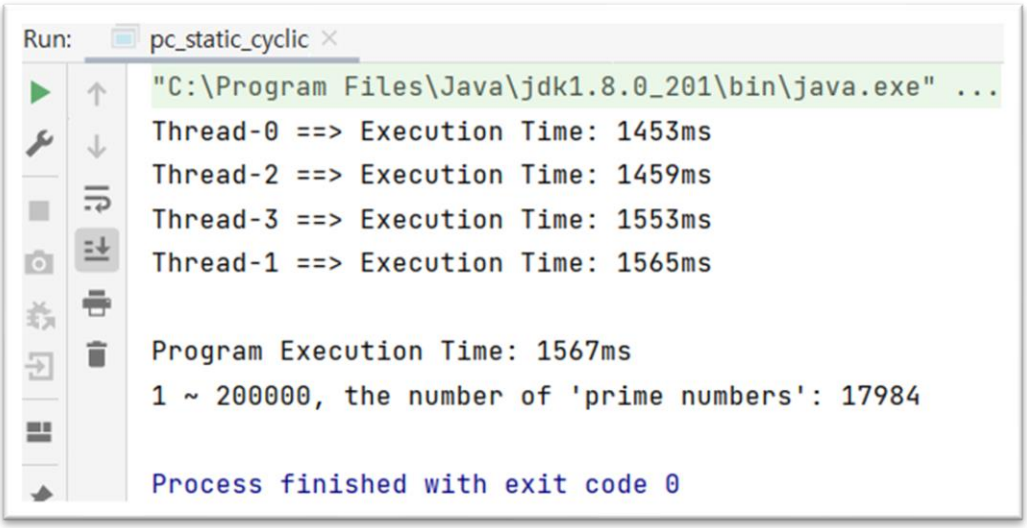

Run:
pc_static_block
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-0 ==> 1 ~ 12500, Execution Time: 63ms
Thread-1 ==> 12501 ~ 25000, Execution Time: 179ms
Thread-2 ==> 25001 ~ 37500, Execution Time: 340ms
Thread-4 ==> 50001 ~ 62500, Execution Time: 467ms
Thread-3 ==> 37501 ~ 50000, Execution Time: 591ms
Thread-8 ==> 100001 ~ 112500, Execution Time: 643ms
Thread-9 ==> 112501 ~ 125000, Execution Time: 705ms
Thread-5 ==> 62501 ~ 75000, Execution Time: 751ms
Thread-6 ==> 75001 ~ 87500, Execution Time: 734ms
Thread-12 ==> 150001 ~ 162500, Execution Time: 873ms
Thread-13 ==> 162501 ~ 175000, Execution Time: 913ms
Thread-7 ==> 87501 ~ 100000, Execution Time: 895ms
Thread-10 ==> 125001 ~ 137500, Execution Time: 973ms
Thread-11 ==> 137501 ~ 150000, Execution Time: 1020ms
Thread-15 ==> 187501 ~ 200000, Execution Time: 1158ms
Thread-14 ==> 175001 ~ 187500, Execution Time: 1175ms
Program Execution Time: 1284ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

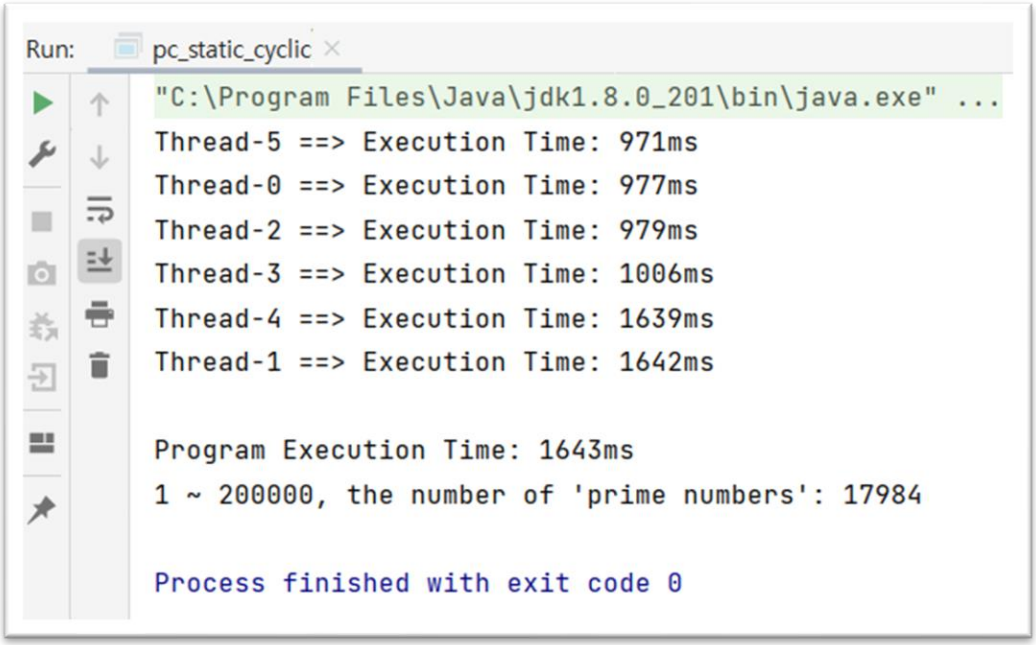


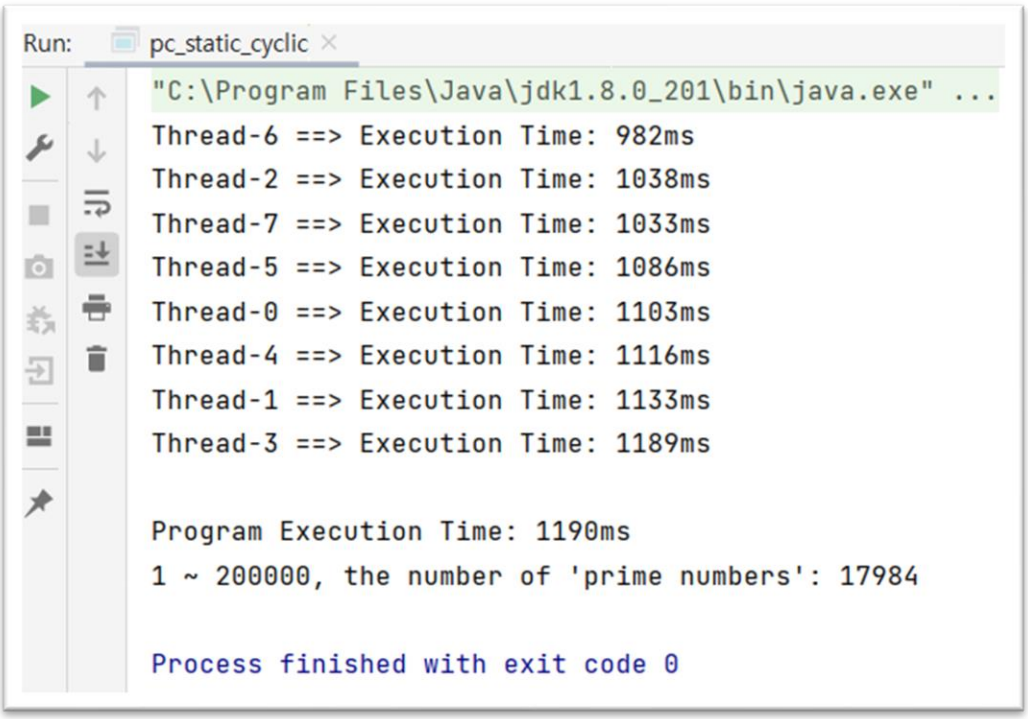
- **Static (Cyclic)**

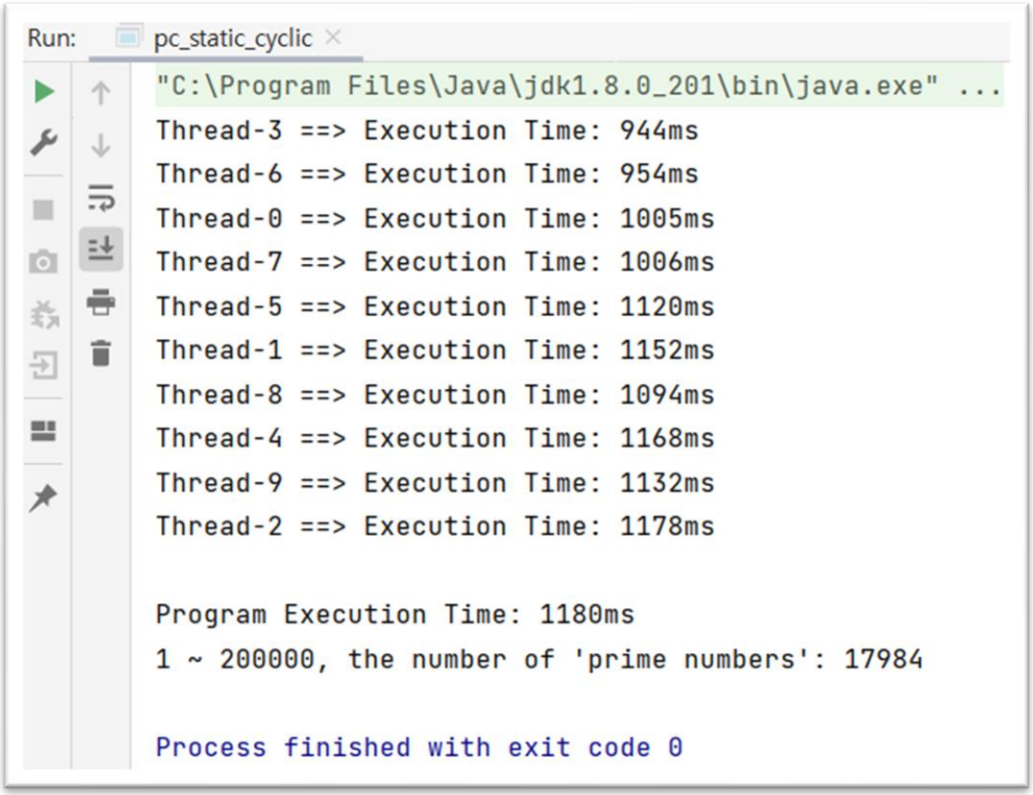


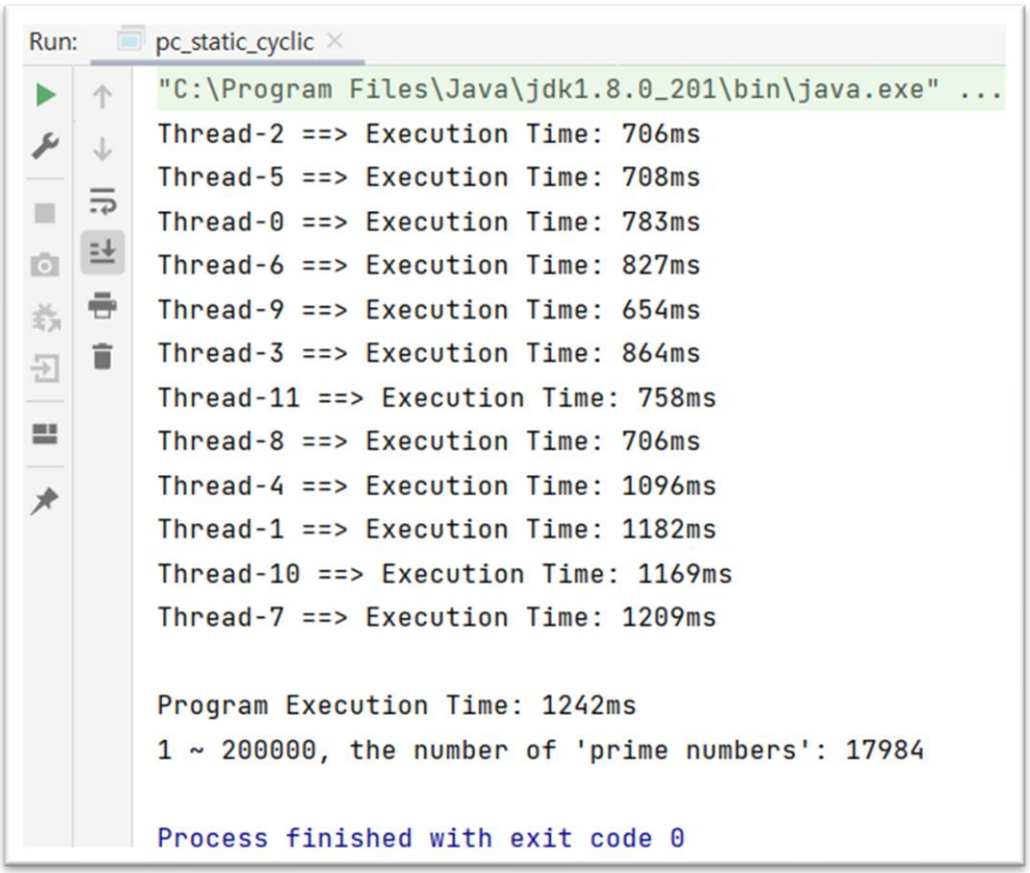

Run: pc_static_cyclic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-1 ==> Execution Time: 2514ms
Thread-0 ==> Execution Time: 2519ms
Program Execution Time: 2520ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

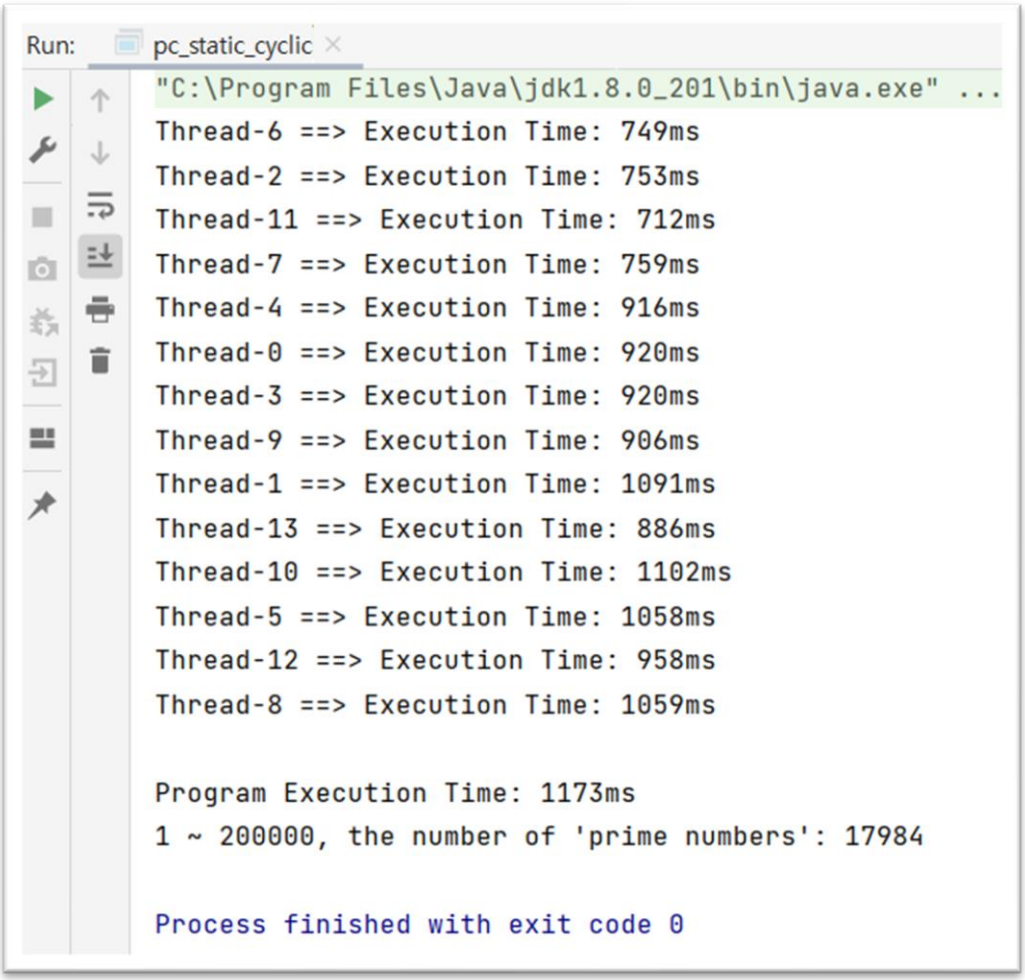

Run: pc_static_cyclic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-0 ==> Execution Time: 1453ms
Thread-2 ==> Execution Time: 1459ms
Thread-3 ==> Execution Time: 1553ms
Thread-1 ==> Execution Time: 1565ms
Program Execution Time: 1567ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

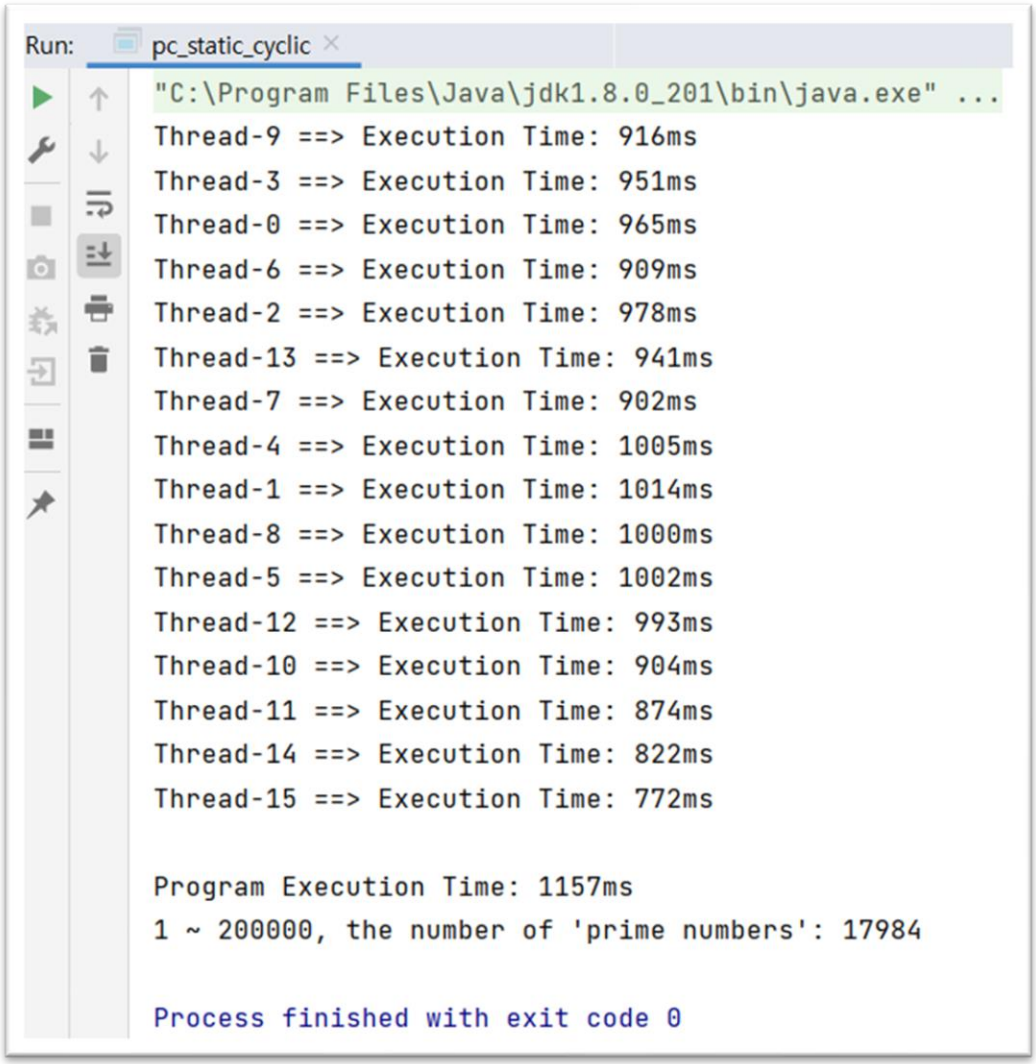

Run: pc_static_cyclic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-5 ==> Execution Time: 971ms
Thread-0 ==> Execution Time: 977ms
Thread-2 ==> Execution Time: 979ms
Thread-3 ==> Execution Time: 1006ms
Thread-4 ==> Execution Time: 1639ms
Thread-1 ==> Execution Time: 1642ms
Program Execution Time: 1643ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

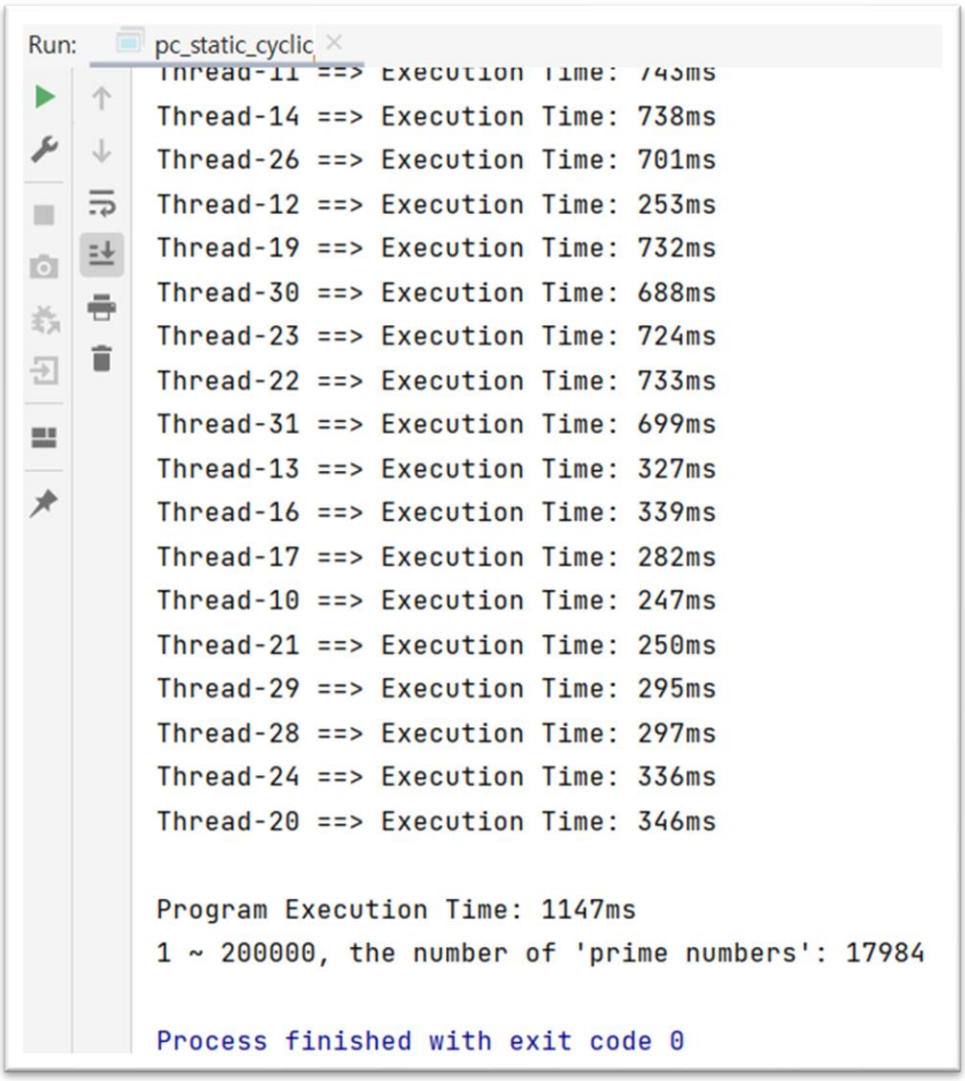

Run:
pc_static_cyclic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-6 ==> Execution Time: 982ms
Thread-2 ==> Execution Time: 1038ms
Thread-7 ==> Execution Time: 1033ms
Thread-5 ==> Execution Time: 1086ms
Thread-0 ==> Execution Time: 1103ms
Thread-4 ==> Execution Time: 1116ms
Thread-1 ==> Execution Time: 1133ms
Thread-3 ==> Execution Time: 1189ms
Program Execution Time: 1190ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0


Run:
pc_static_cyclic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-3 ==> Execution Time: 944ms
Thread-6 ==> Execution Time: 954ms
Thread-0 ==> Execution Time: 1005ms
Thread-7 ==> Execution Time: 1006ms
Thread-5 ==> Execution Time: 1120ms
Thread-1 ==> Execution Time: 1152ms
Thread-8 ==> Execution Time: 1094ms
Thread-4 ==> Execution Time: 1168ms
Thread-9 ==> Execution Time: 1132ms
Thread-2 ==> Execution Time: 1178ms
Program Execution Time: 1180ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

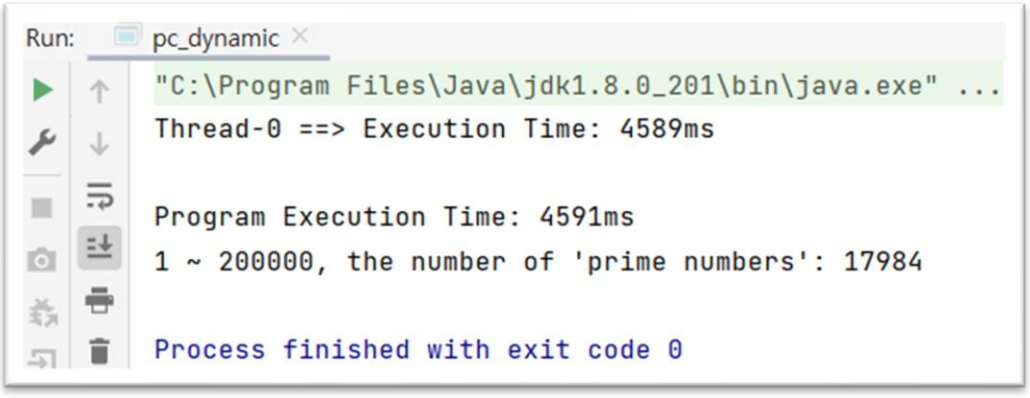

Run:
pc_static_cyclic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-2 ==> Execution Time: 706ms
Thread-5 ==> Execution Time: 708ms
Thread-0 ==> Execution Time: 783ms
Thread-6 ==> Execution Time: 827ms
Thread-9 ==> Execution Time: 654ms
Thread-3 ==> Execution Time: 864ms
Thread-11 ==> Execution Time: 758ms
Thread-8 ==> Execution Time: 706ms
Thread-4 ==> Execution Time: 1096ms
Thread-1 ==> Execution Time: 1182ms
Thread-10 ==> Execution Time: 1169ms
Thread-7 ==> Execution Time: 1209ms
Program Execution Time: 1242ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

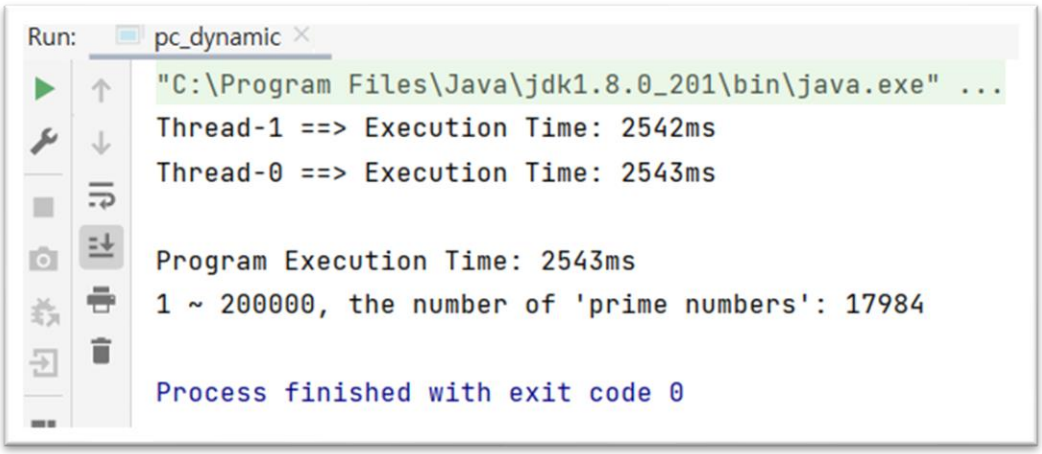

Run:
pc_static_cyclic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-6 ==> Execution Time: 749ms
Thread-2 ==> Execution Time: 753ms
Thread-11 ==> Execution Time: 712ms
Thread-7 ==> Execution Time: 759ms
Thread-4 ==> Execution Time: 916ms
Thread-0 ==> Execution Time: 920ms
Thread-3 ==> Execution Time: 920ms
Thread-9 ==> Execution Time: 906ms
Thread-1 ==> Execution Time: 1091ms
Thread-13 ==> Execution Time: 886ms
Thread-10 ==> Execution Time: 1102ms
Thread-5 ==> Execution Time: 1058ms
Thread-12 ==> Execution Time: 958ms
Thread-8 ==> Execution Time: 1059ms
Program Execution Time: 1173ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

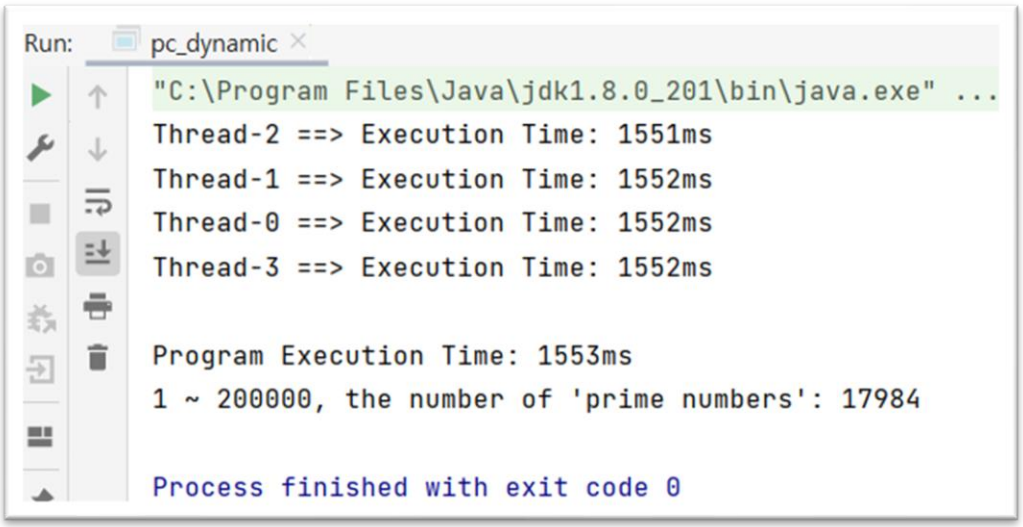

Run:
pc_static_cyclic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-9 ==> Execution Time: 916ms
Thread-3 ==> Execution Time: 951ms
Thread-0 ==> Execution Time: 965ms
Thread-6 ==> Execution Time: 909ms
Thread-2 ==> Execution Time: 978ms
Thread-13 ==> Execution Time: 941ms
Thread-7 ==> Execution Time: 902ms
Thread-4 ==> Execution Time: 1005ms
Thread-1 ==> Execution Time: 1014ms
Thread-8 ==> Execution Time: 1000ms
Thread-5 ==> Execution Time: 1002ms
Thread-12 ==> Execution Time: 993ms
Thread-10 ==> Execution Time: 904ms
Thread-11 ==> Execution Time: 874ms
Thread-14 ==> Execution Time: 822ms
Thread-15 ==> Execution Time: 772ms
Program Execution Time: 1157ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

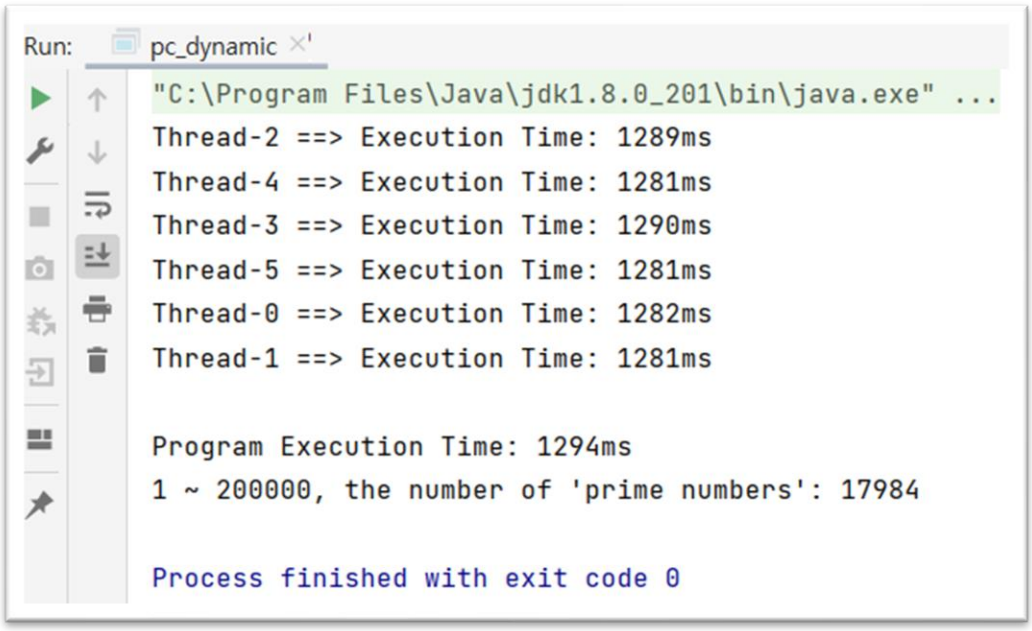

Run:
pc_static_cyclic
Thread-14 ==> Execution Time: 738ms
Thread-26 ==> Execution Time: 701ms
Thread-12 ==> Execution Time: 253ms
Thread-19 ==> Execution Time: 732ms
Thread-30 ==> Execution Time: 688ms
Thread-23 ==> Execution Time: 724ms
Thread-22 ==> Execution Time: 733ms
Thread-31 ==> Execution Time: 699ms
Thread-13 ==> Execution Time: 327ms
Thread-16 ==> Execution Time: 339ms
Thread-17 ==> Execution Time: 282ms
Thread-10 ==> Execution Time: 247ms
Thread-21 ==> Execution Time: 250ms
Thread-29 ==> Execution Time: 295ms
Thread-28 ==> Execution Time: 297ms
Thread-24 ==> Execution Time: 336ms
Thread-20 ==> Execution Time: 346ms
Program Execution Time: 1147ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

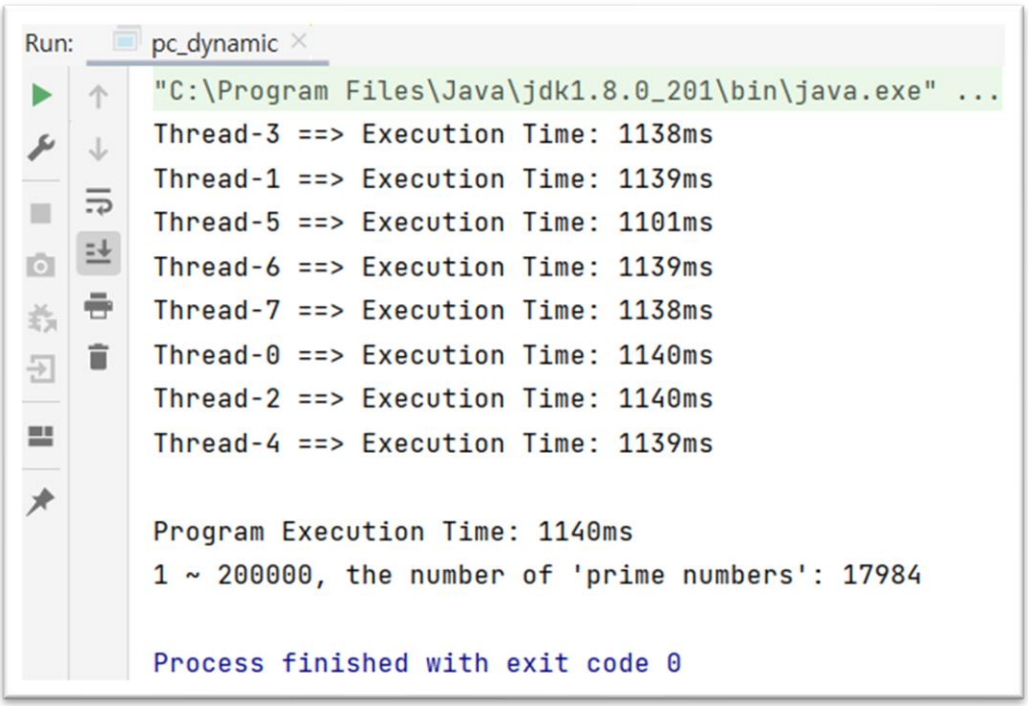
- **Dynamic**

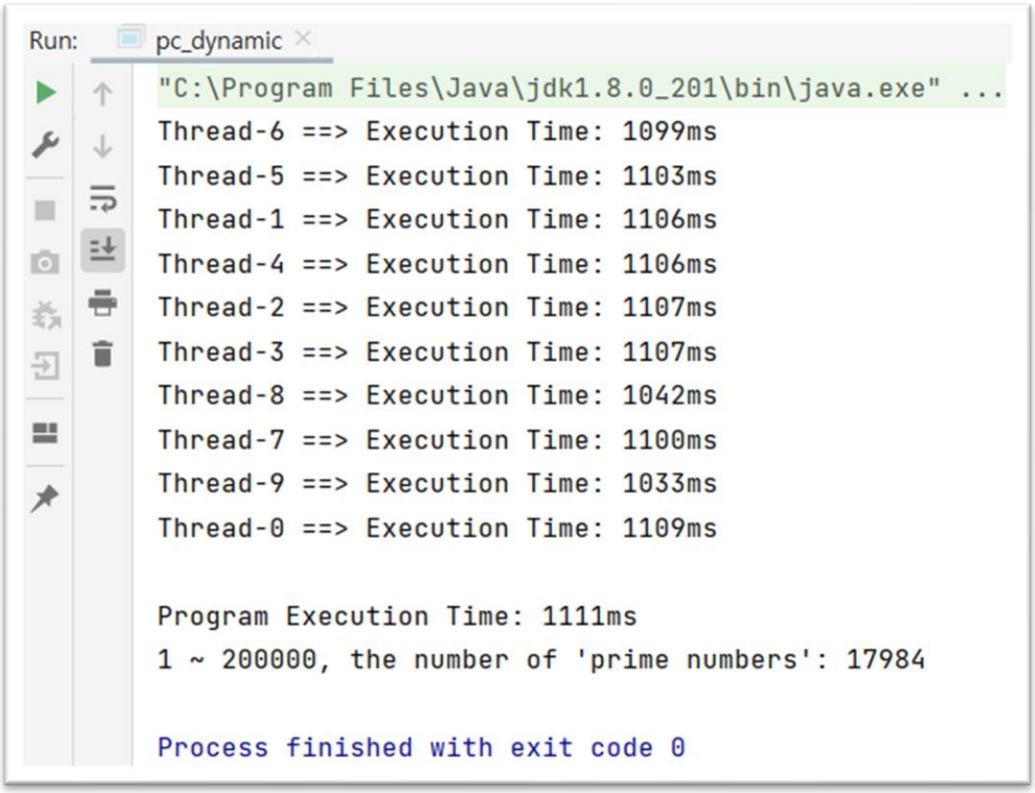

Run:
pc_dynamic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-0 ==> Execution Time: 4589ms
Program Execution Time: 4591ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

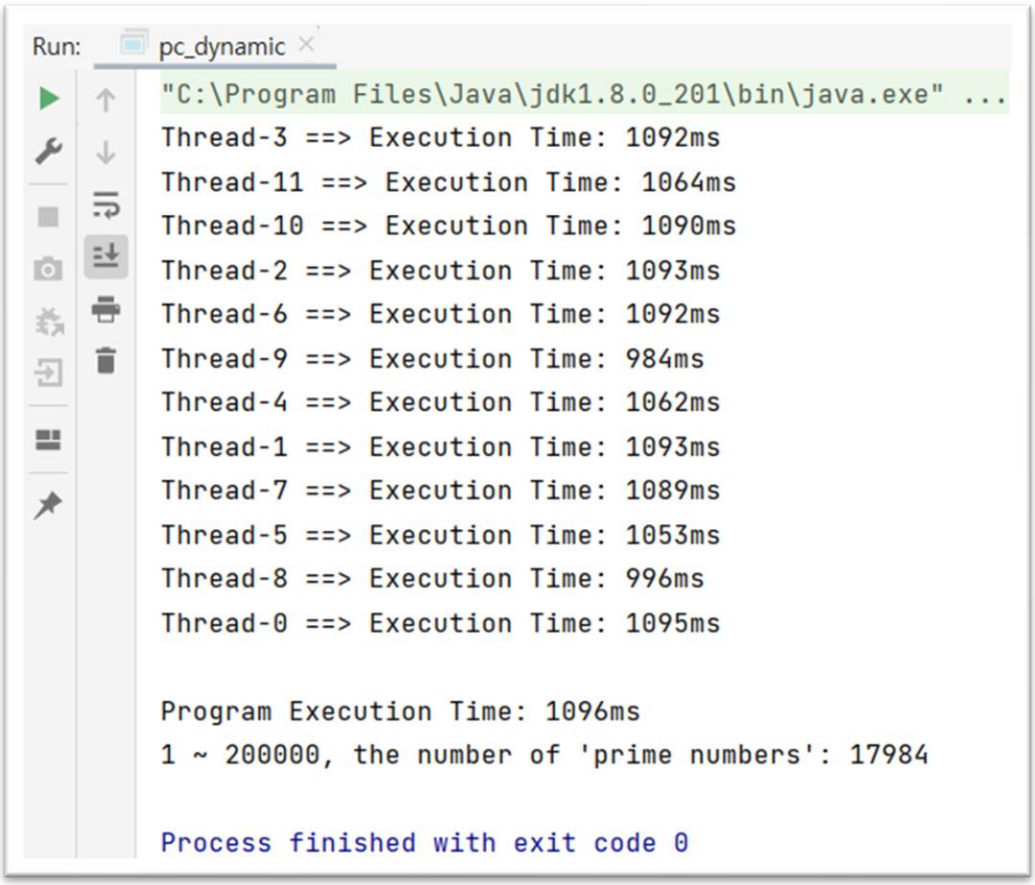

Run:
pc_dynamic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-1 ==> Execution Time: 2542ms
Thread-0 ==> Execution Time: 2543ms
Program Execution Time: 2543ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

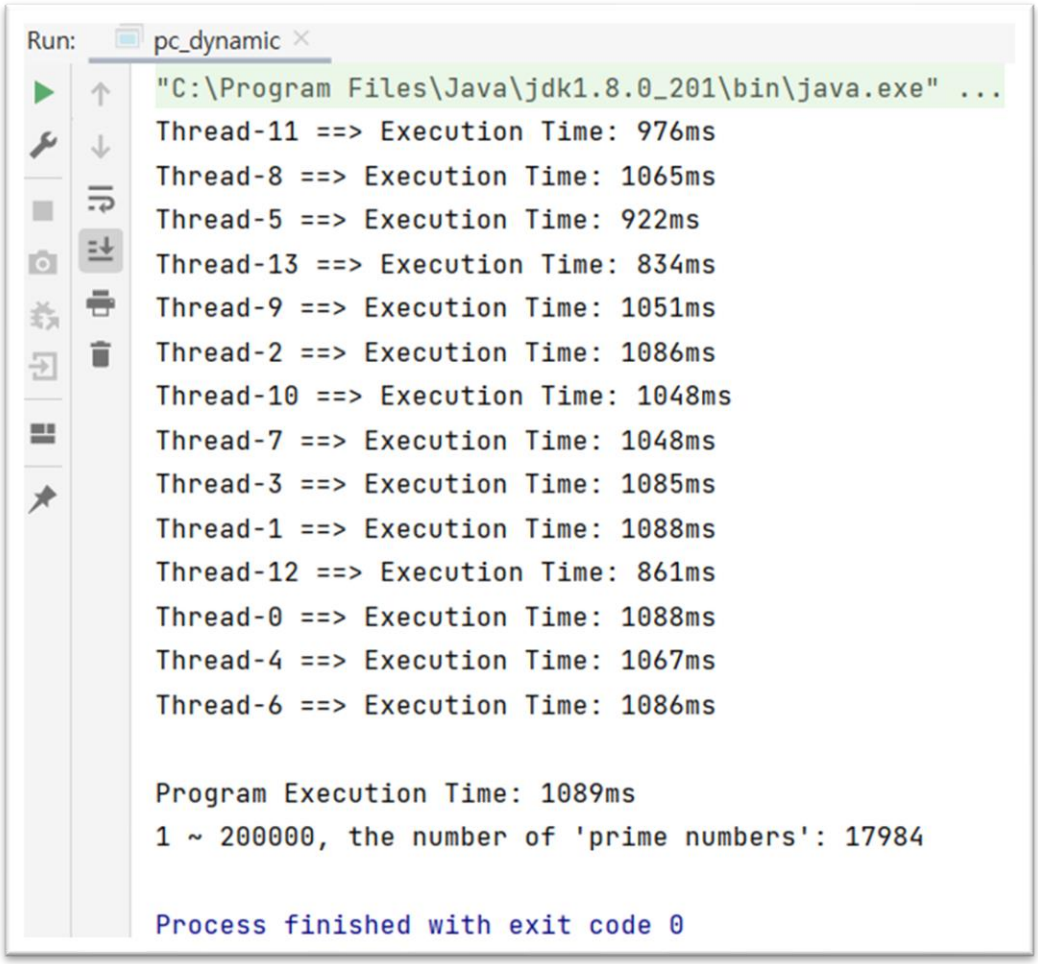

Run:
pc_dynamic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-2 ==> Execution Time: 1551ms
Thread-1 ==> Execution Time: 1552ms
Thread-0 ==> Execution Time: 1552ms
Thread-3 ==> Execution Time: 1552ms
Program Execution Time: 1553ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

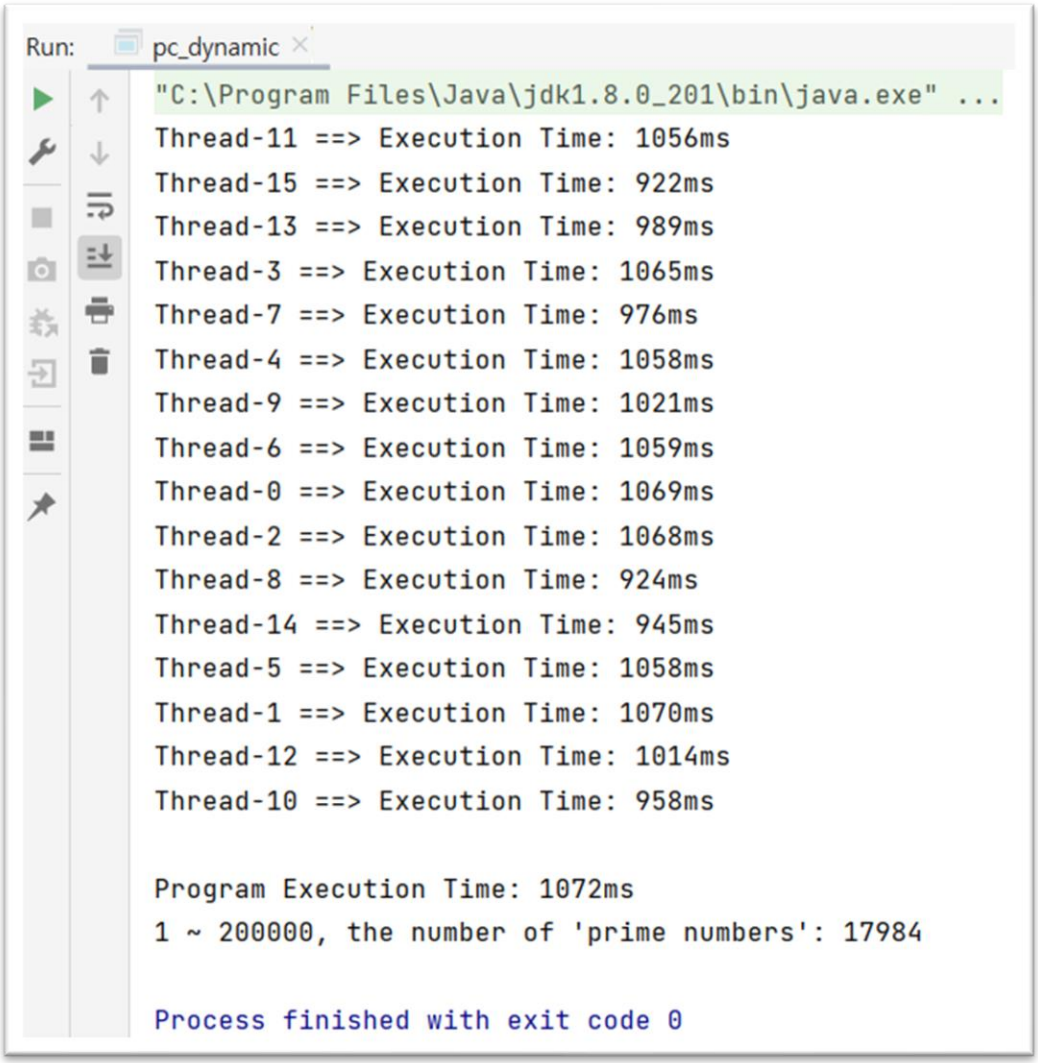

Run:
pc_dynamic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-2 ==> Execution Time: 1289ms
Thread-4 ==> Execution Time: 1281ms
Thread-3 ==> Execution Time: 1290ms
Thread-5 ==> Execution Time: 1281ms
Thread-0 ==> Execution Time: 1282ms
Thread-1 ==> Execution Time: 1281ms
Program Execution Time: 1294ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

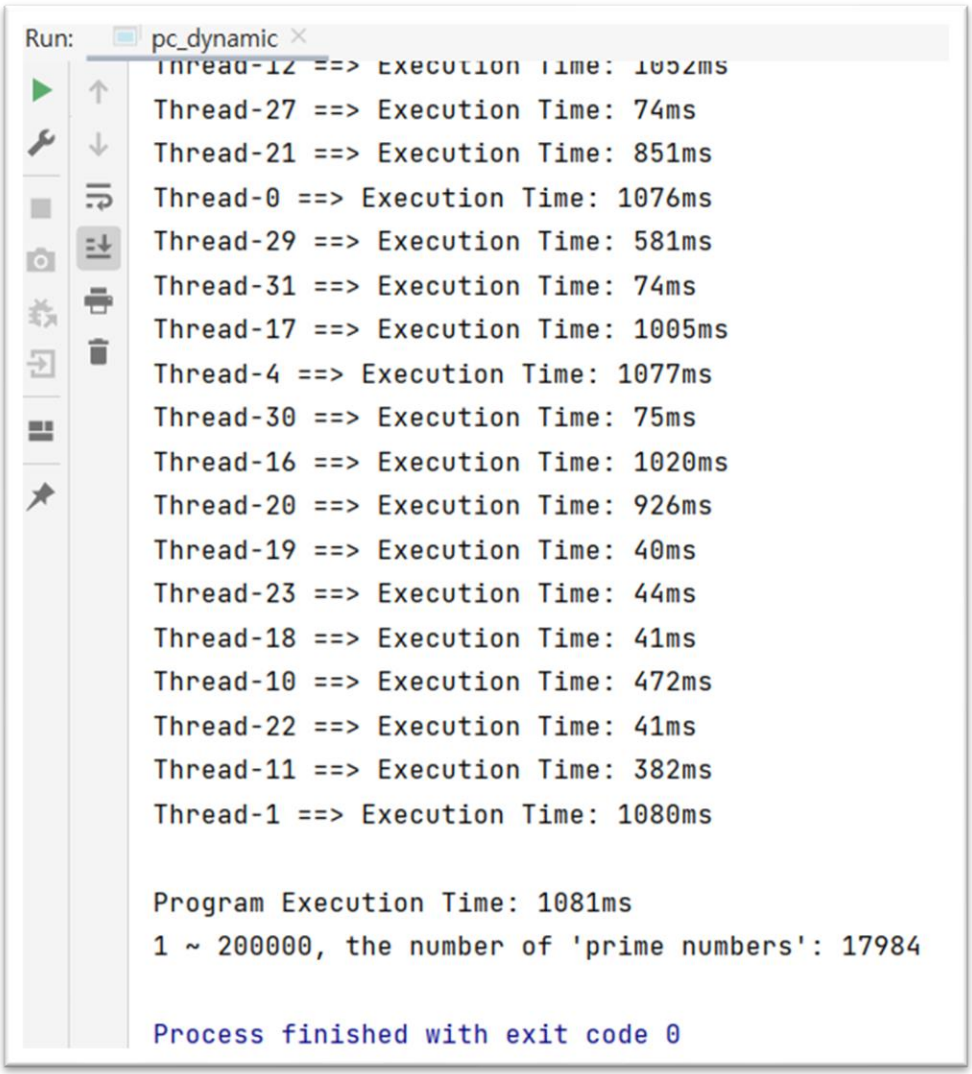

Run:
pc_dynamic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-3 ==> Execution Time: 1138ms
Thread-1 ==> Execution Time: 1139ms
Thread-5 ==> Execution Time: 1101ms
Thread-6 ==> Execution Time: 1139ms
Thread-7 ==> Execution Time: 1138ms
Thread-0 ==> Execution Time: 1140ms
Thread-2 ==> Execution Time: 1140ms
Thread-4 ==> Execution Time: 1139ms
Program Execution Time: 1140ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0


Run:
pc_dynamic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-6 ==> Execution Time: 1099ms
Thread-5 ==> Execution Time: 1103ms
Thread-1 ==> Execution Time: 1106ms
Thread-4 ==> Execution Time: 1106ms
Thread-2 ==> Execution Time: 1107ms
Thread-3 ==> Execution Time: 1107ms
Thread-8 ==> Execution Time: 1042ms
Thread-7 ==> Execution Time: 1100ms
Thread-9 ==> Execution Time: 1033ms
Thread-0 ==> Execution Time: 1109ms
Program Execution Time: 1111ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0


Run:
pc_dynamic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-3 ==> Execution Time: 1092ms
Thread-11 ==> Execution Time: 1064ms
Thread-10 ==> Execution Time: 1090ms
Thread-2 ==> Execution Time: 1093ms
Thread-6 ==> Execution Time: 1092ms
Thread-9 ==> Execution Time: 984ms
Thread-4 ==> Execution Time: 1062ms
Thread-1 ==> Execution Time: 1093ms
Thread-7 ==> Execution Time: 1089ms
Thread-5 ==> Execution Time: 1053ms
Thread-8 ==> Execution Time: 996ms
Thread-0 ==> Execution Time: 1095ms
Program Execution Time: 1096ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

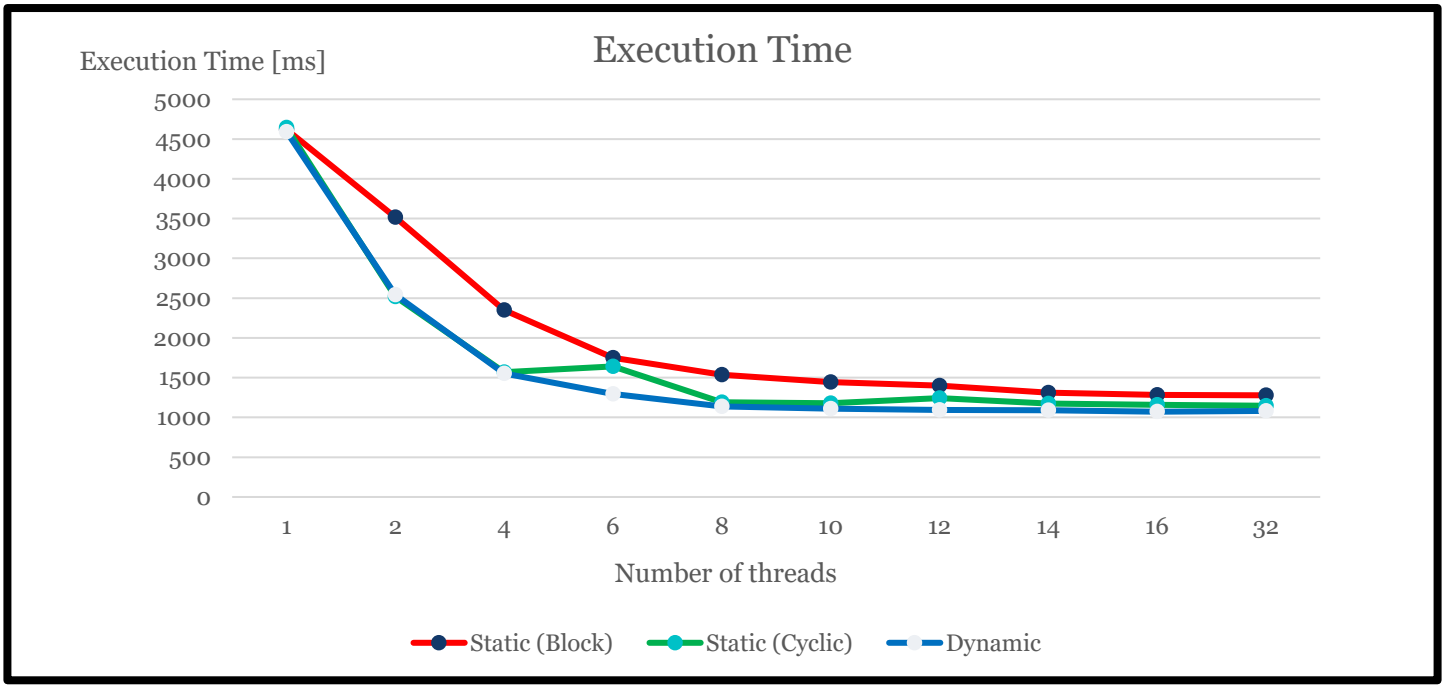

Run:
pc_dynamic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-11 ==> Execution Time: 976ms
Thread-8 ==> Execution Time: 1065ms
Thread-5 ==> Execution Time: 922ms
Thread-13 ==> Execution Time: 834ms
Thread-9 ==> Execution Time: 1051ms
Thread-2 ==> Execution Time: 1086ms
Thread-10 ==> Execution Time: 1048ms
Thread-7 ==> Execution Time: 1048ms
Thread-3 ==> Execution Time: 1085ms
Thread-1 ==> Execution Time: 1088ms
Thread-12 ==> Execution Time: 861ms
Thread-0 ==> Execution Time: 1088ms
Thread-4 ==> Execution Time: 1067ms
Thread-6 ==> Execution Time: 1086ms
Program Execution Time: 1089ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

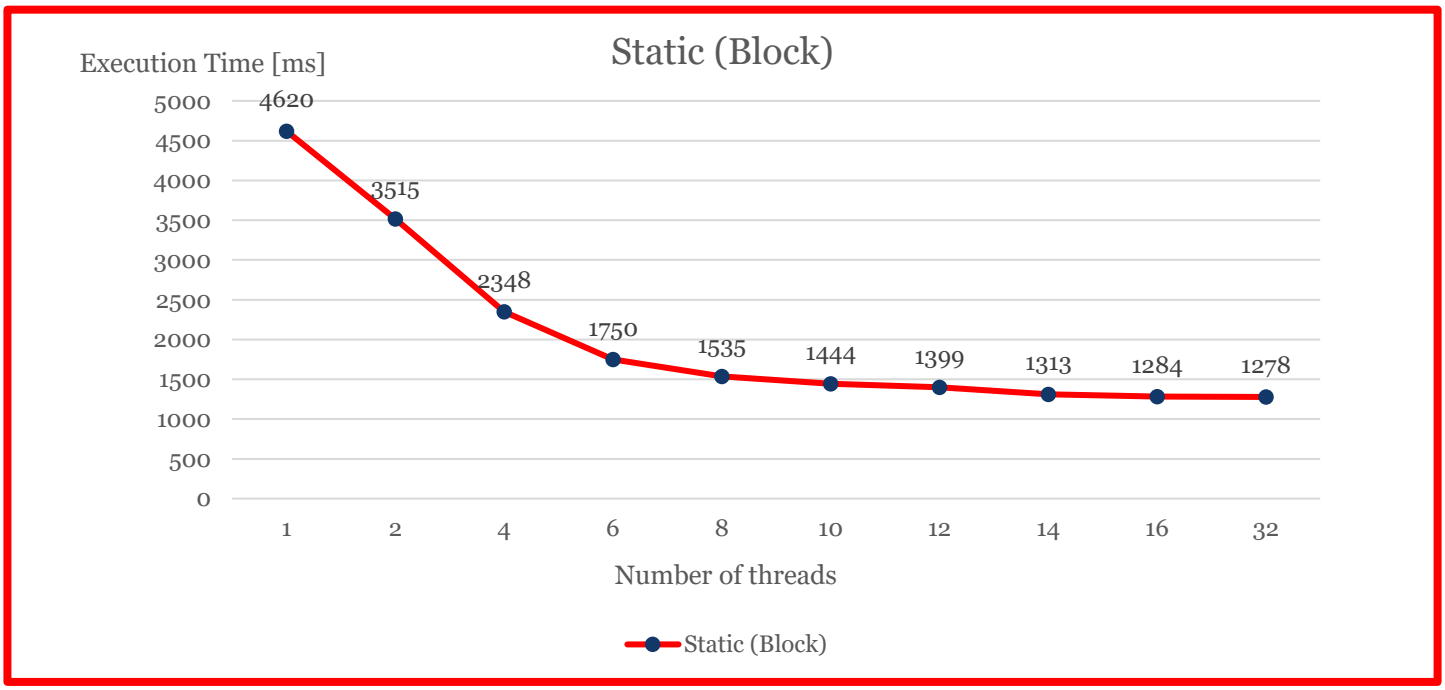

Run:
pc_dynamic
"C:\Program Files\Java\jdk1.8.0_201\bin\java.exe" ...
Thread-11 ==> Execution Time: 1056ms
Thread-15 ==> Execution Time: 922ms
Thread-13 ==> Execution Time: 989ms
Thread-3 ==> Execution Time: 1065ms
Thread-7 ==> Execution Time: 976ms
Thread-4 ==> Execution Time: 1058ms
Thread-9 ==> Execution Time: 1021ms
Thread-6 ==> Execution Time: 1059ms
Thread-0 ==> Execution Time: 1069ms
Thread-2 ==> Execution Time: 1068ms
Thread-8 ==> Execution Time: 924ms
Thread-14 ==> Execution Time: 945ms
Thread-5 ==> Execution Time: 1058ms
Thread-1 ==> Execution Time: 1070ms
Thread-12 ==> Execution Time: 1014ms
Thread-10 ==> Execution Time: 958ms
Program Execution Time: 1072ms
1 ~ 200000, the number of 'prime numbers': 17984
Process finished with exit code 0

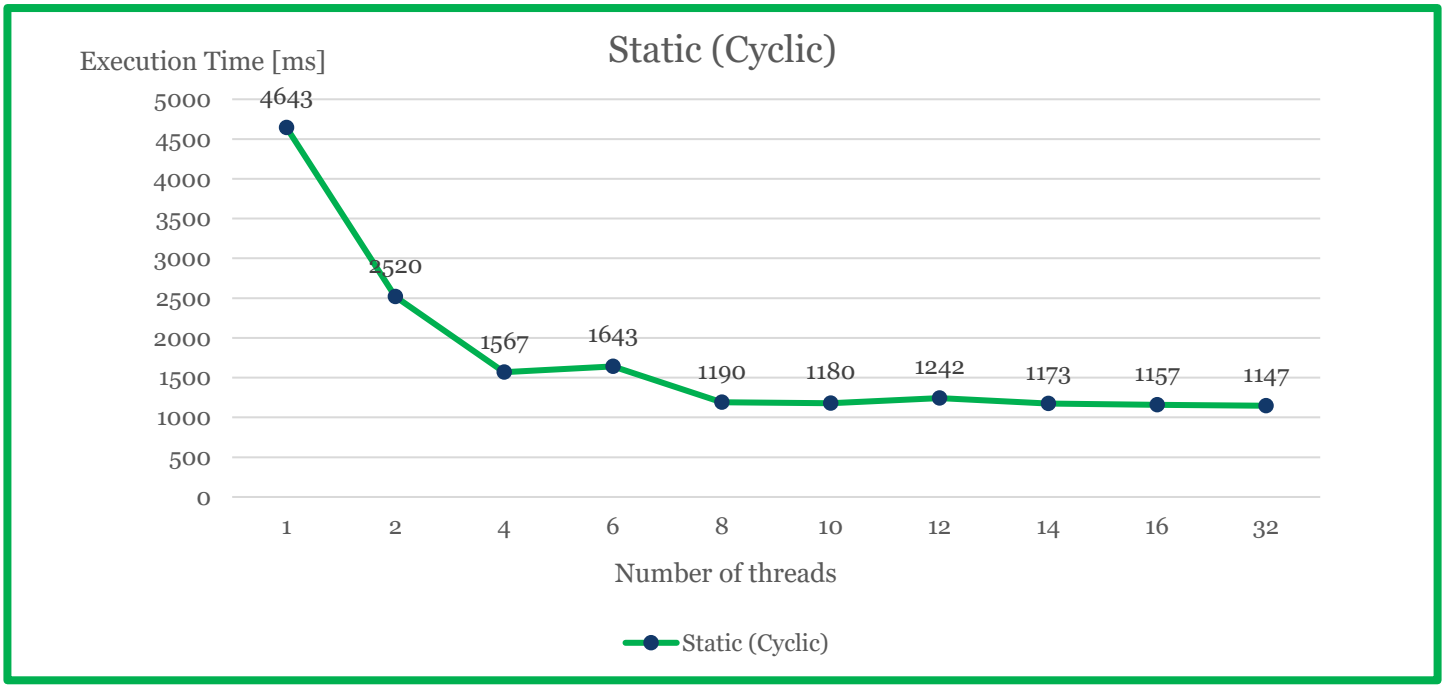


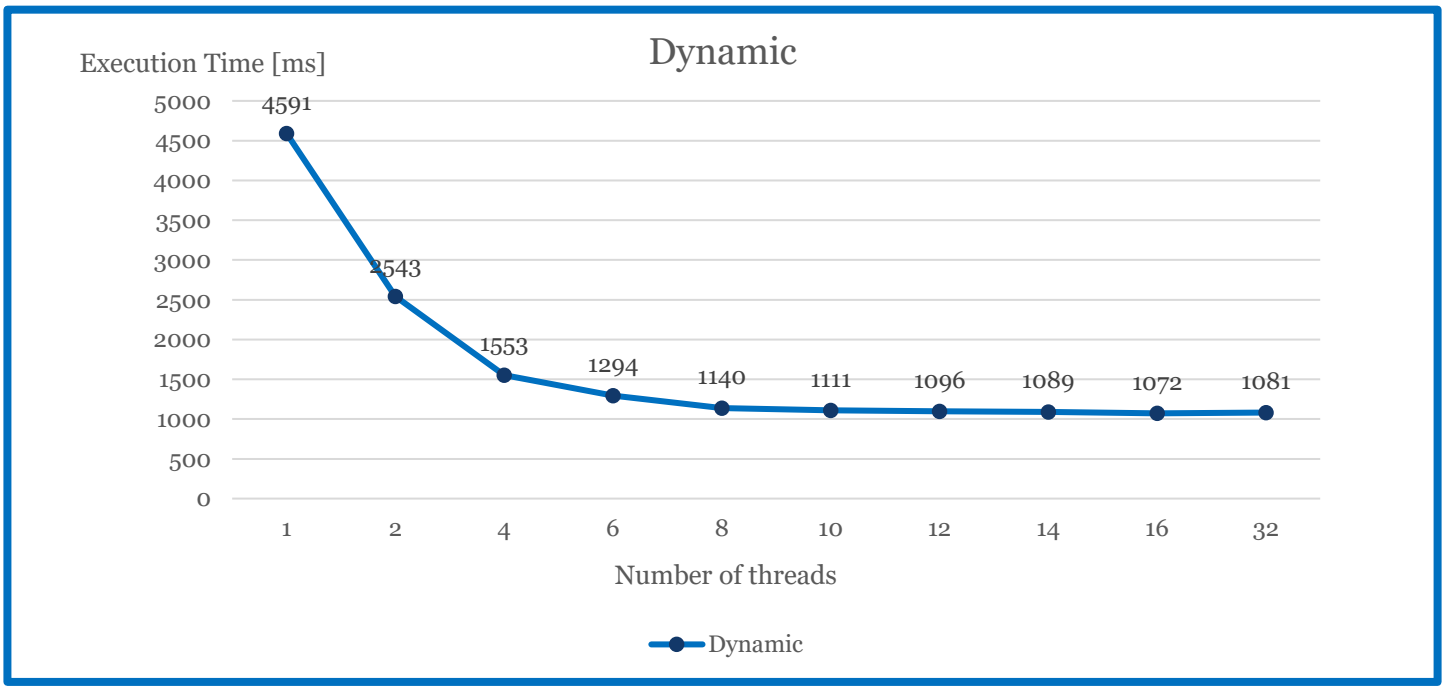
- **Execution Time**

Exec time	1	2	4	6	8	10	12	14	16	32
Static (Block)	4620ms	3515ms	2348ms	1750ms	1535ms	1444ms	1399ms	1313ms	1284ms	1278ms
Static (Cyclic) [task size: 10 numbers]	4643ms	2520ms	1567ms	1643ms	1190ms	1180ms	1242ms	1173ms	1157ms	1147ms
Dynamic [task size: 10 numbers]	4591ms	2543ms	1553ms	1294ms	1140ms	1111ms	1096ms	1089ms	1072ms	1081ms


Execution Time
Execution Time [ms]
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1
2
4
6
8
10
12
14
16
32
Number of threads
Static (Block)
Static (Cyclic)
Dynamic

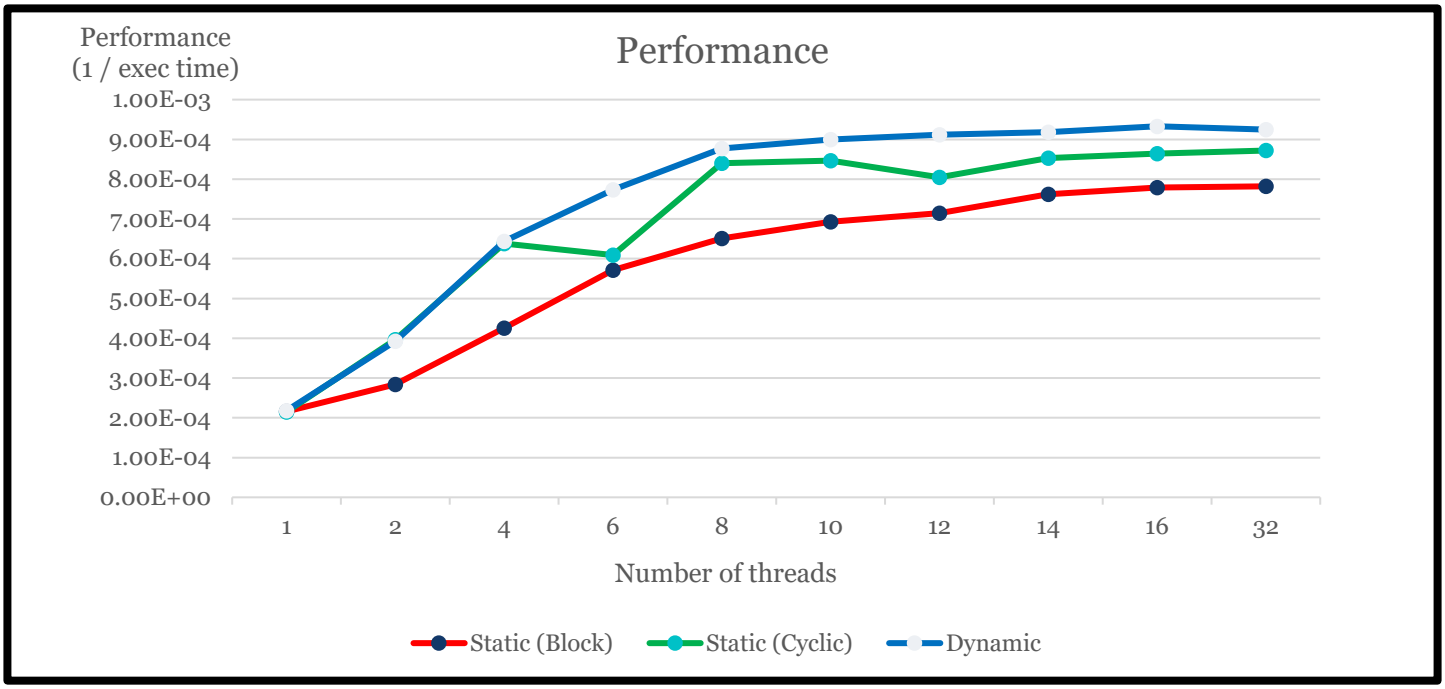

Static (Block)
Execution Time [ms]
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
4620
3515
2348
1750
1535
1444
1399
1313
1284
1278
1
2
4
6
8
10
12
14
16
32
Number of threads
Static (Block)

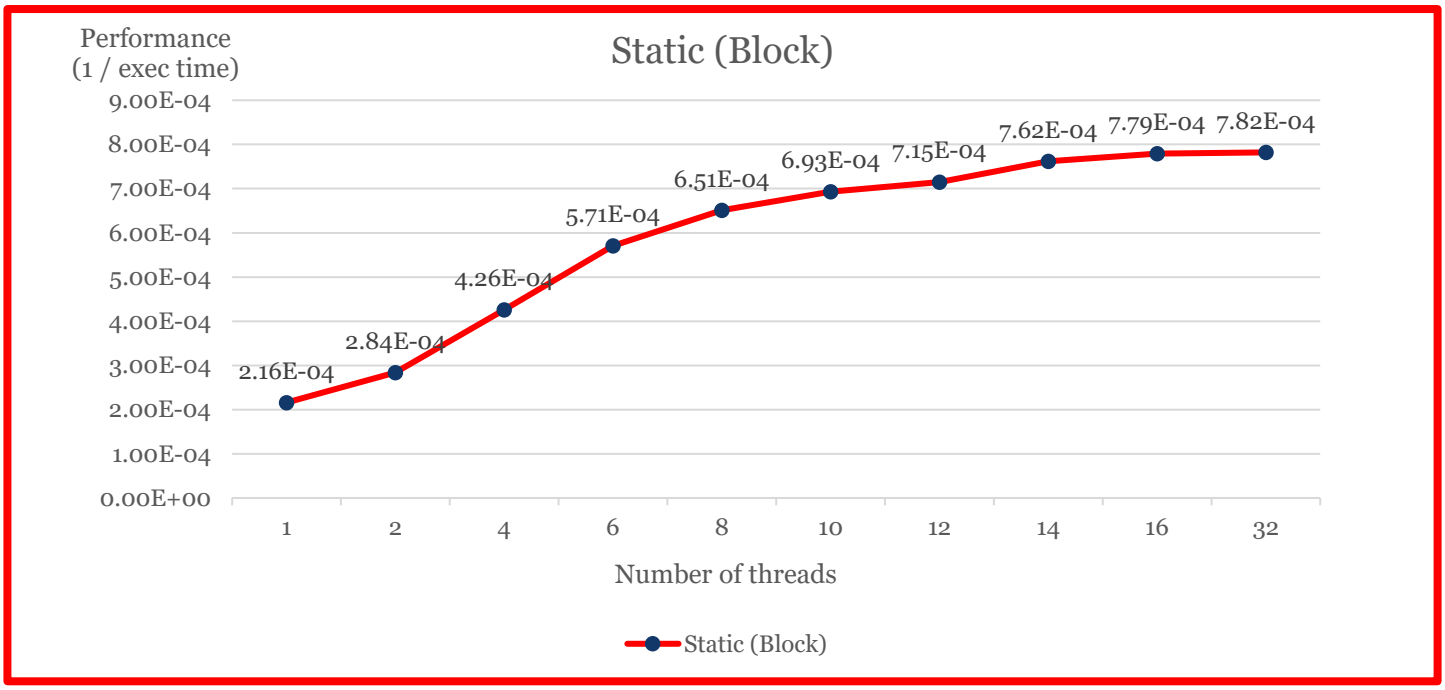


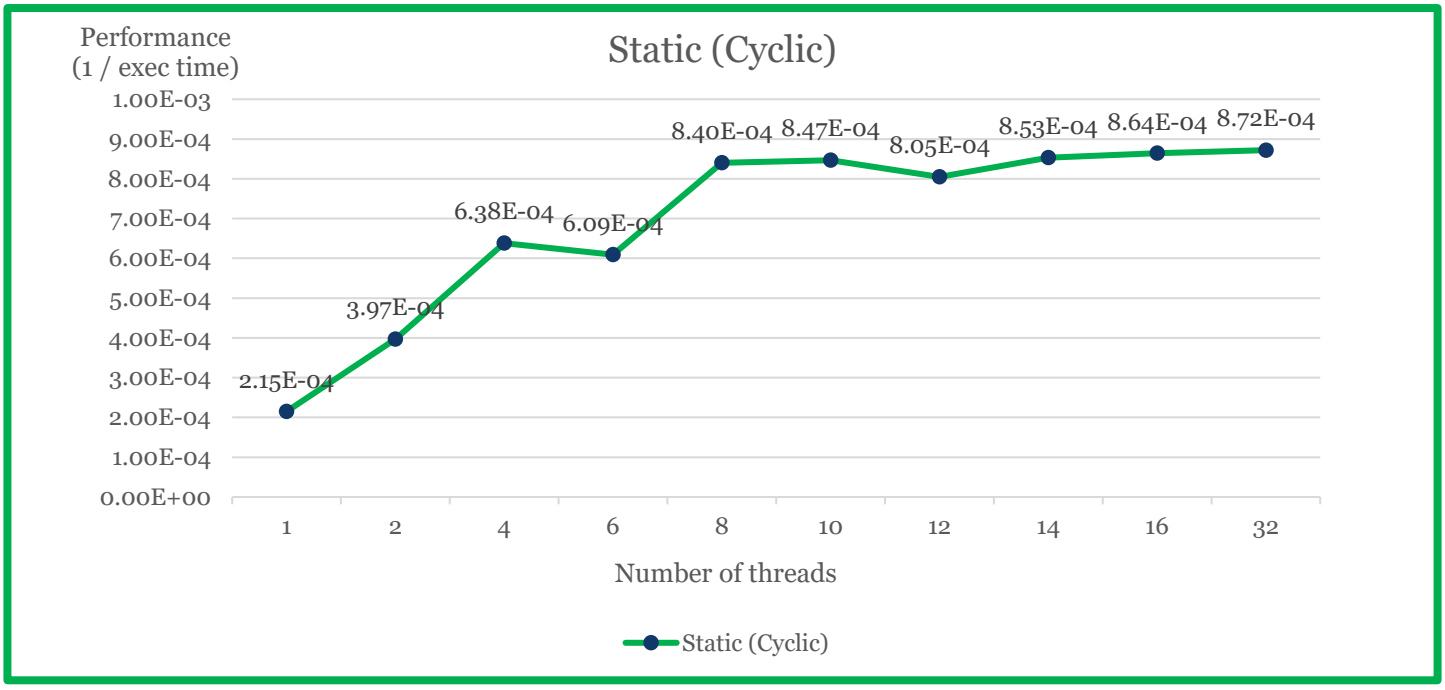


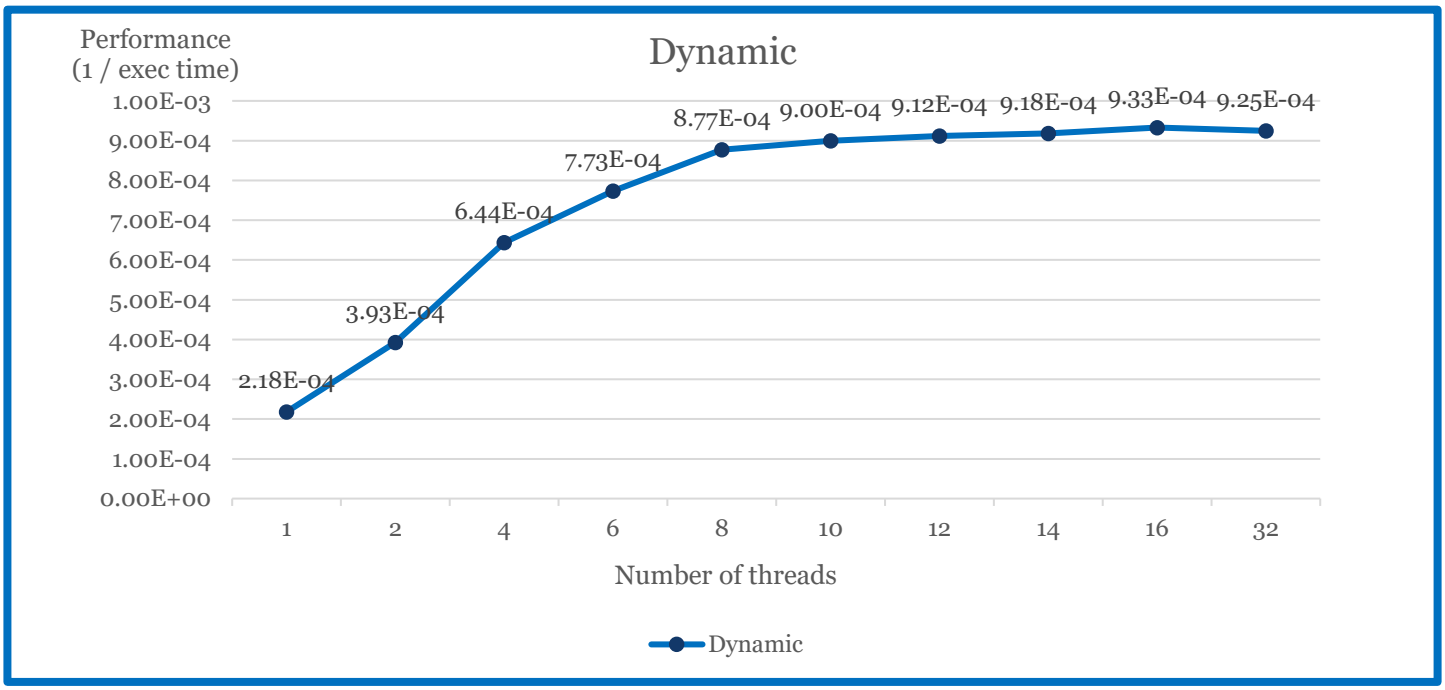
- **Performance**

Performance (1/exec time)	1	2	4	6	8	10	12	14	16	32
Static (Block)	2.16e-4	2.84e-4	4.26e-4	5.71e-4	6.51e-4	6.93e-4	7.15e-4	7.62e-4	7.79e-4	7.82e-4
Static (Cyclic) [task size: 10 numbers]	2.15e-4	3.97e-4	6.38e-4	6.09e-4	8.40e-4	8.47e-4	8.05e-4	8.53e-4	8.64e-4	8.72e-4
Dynamic [task size: 10 numbers]	2.18e-4	3.93e-4	6.44e-4	7.73e-4	8.77e-4	9.00e-4	9.12e-4	9.18e-4	9.33e-4	9.25e-4


Performance
Performance
(1 / exec time)
1.00E-03
9.00E-04
8.00E-04
7.00E-04
6.00E-04
5.00E-04
4.00E-04
3.00E-04
2.00E-04
1.00E-04
0.00E+00
1
2
4
6
8
10
12
14
16
32
Number of threads
Static (Block)
Static (Cyclic)
Dynamic


Performance
(1 / exec time)
Static (Block)
9.00E-04
8.00E-04
7.00E-04
6.00E-04
5.00E-04
4.00E-04
3.00E-04
2.00E-04
1.00E-04
0.00E+00
2.16E-04
2.84E-04
4.26E-04
5.71E-04
6.51E-04
6.93E-04
7.15E-04
7.62E-04
7.79E-04
7.82E-04
1
2
4
6
8
10
12
14
16
32
Number of threads
Static (Block)





[Explanation/Analysis on the Results]

In the three load balancing approaches, when the number of threads increases, the execution time decreases and performance is improved. But at some points, although the number of threads increases, performance enhancement is very small. It's because creating a lot of threads is the same as making large overheads. If the number of threads is small (=Coarse-grain Parallelism), then there is low overhead. But if the number of threads is very large (=Fine-grain Parallelism), then there is high overhead and less opportunity for performance enhancement. So, considering load balancing and overhead, we need to decide how many threads we use.