```
/Users/zuzannafurtak/Library/Java/JavaVirtualMachines/
corretto-17.0.8/Contents/Home/bin/java -javaagent:/
Applications/IntelliJ IDEA.app/Contents/lib/idea_rt.
jar=60774:/Applications/IntelliJ IDEA.app/Contents/bin
 -Dfile.encoding=UTF-8 -classpath /Users/zuzannafurtak
/studia/las_palmas/big_data/big-data-tasks/assignment-
2/target/classes:/Users/zuzannafurtak/.m2/repository/
org/openjdk/jmh/jmh-core/1.32/jmh-core-1.32.jar:/Users
/zuzannafurtak/.m2/repository/net/sf/jopt-simple/jopt-
simple/4.6/jopt-simple-4.6.jar:/Users/zuzannafurtak/.
m2/repository/org/apache/commons/commons-math3/3.2/
commons-math3-3.2.jar:/Users/zuzannafurtak/.m2/
repository/org/openjdk/jmh/jmh-generator-annprocess/1.
32/jmh-generator-annprocess-1.32.jar:/Users/
zuzannafurtak/.m2/repository/org/tallison/jmatio/1.5/
jmatio-1.5.jar:/Users/zuzannafurtak/.m2/repository/org
/slf4j/slf4j-api/1.7.25/slf4j-api-1.7.25.jar com.
matrix.MatrixMultiplicationBenchmark
# JMH version: 1.32
# VM version: JDK 17.0.8, OpenJDK 64-Bit Server VM, 17
.0.8+7-LTS
# VM invoker: /Users/zuzannafurtak/Library/Java/
JavaVirtualMachines/corretto-17.0.8/Contents/Home/bin/
java
# VM options: -javaagent:/Applications/IntelliJ IDEA.
app/Contents/lib/idea_rt.jar=60774:/Applications/
IntelliJ IDEA.app/Contents/bin -Dfile.encoding=UTF-8
# Blackhole mode: full + dont-inline hint
# Warmup: 5 iterations, 1 s each
# Measurement: 10 iterations, 1 s each
# Timeout: 10 min per iteration
# Threads: 1 thread, will synchronize iterations
# Benchmark mode: Sampling time
# Benchmark: com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices
# Parameters: (n = 10)

# Run progress: 0.00% complete, ETA 00:02:15
# Fork: 1 of 1
# Warmup Iteration   1: ≈ 10⁻⁴ ms/op
# Warmup Iteration   2: ≈ 10⁻⁴ ms/op
```

```
# Warmup Iteration   3: ≈ 10⁻⁴ ms/op
# Warmup Iteration   4: ≈ 10⁻⁴ ms/op
# Warmup Iteration   5: ≈ 10⁻⁴ ms/op
Iteration   1: ≈ 10⁻⁴ ms/op
                 multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.9999: 0.007
 ms/op
                 multiplySparseMatrices·p1.00:   0.008
 ms/op

Iteration   2: ≈ 10⁻⁴ ms/op
                 multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.9999: 0.008
 ms/op
                 multiplySparseMatrices·p1.00:   0.012
 ms/op

Iteration   3: ≈ 10⁻⁴ ms/op
                 multiplySparseMatrices·p0.00:   ≈ 0
```

```
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.9999: 0.003
 ms/op
                 multiplySparseMatrices·p1.00:   0.012
 ms/op

Iteration   4: ≈ 10⁻⁴ ms/op
                 multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.9999: 0.001
 ms/op
                 multiplySparseMatrices·p1.00:   0.005
 ms/op

Iteration   5: ≈ 10⁻⁴ ms/op
                 multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
```

```
                    multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                    multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                    multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                    multiplySparseMatrices·p0.9999: 0.008
 ms/op
                    multiplySparseMatrices·p1.00:   0.303
 ms/op

Iteration   6: ≈ 10⁻⁴ ms/op
                    multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                    multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                    multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                    multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                    multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                    multiplySparseMatrices·p0.999:  0.001
 ms/op
                    multiplySparseMatrices·p0.9999: 0.025
 ms/op
                    multiplySparseMatrices·p1.00:   0.034
 ms/op

Iteration   7: ≈ 10⁻⁴ ms/op
                    multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                    multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                    multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                    multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                    multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                    multiplySparseMatrices·p0.999:  ≈ 10
```

```
⁻⁴ ms/op
                 multiplySparseMatrices·p0.9999: 0.007
 ms/op
                 multiplySparseMatrices·p1.00:   0.040
 ms/op

Iteration   8: ≈ 10⁻⁴ ms/op
                 multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.999:  0.001
 ms/op
                 multiplySparseMatrices·p0.9999: 0.009
 ms/op
                 multiplySparseMatrices·p1.00:   0.360
 ms/op

Iteration   9: ≈ 10⁻⁴ ms/op
                 multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.9999: 0.005
 ms/op
                 multiplySparseMatrices·p1.00:   0.005
 ms/op
```

```
Iteration  10: ≈ 10⁻⁴ ms/op
                 multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.9999: 0.006
 ms/op
                 multiplySparseMatrices·p1.00:   0.012
 ms/op



Result "com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices":
  N = 258315
  mean =     ≈ 10⁻⁴ ±(99.9%) 0.001 ms/op

  Histogram, ms/op:
    [0.000, 0.025) = 258310
    [0.025, 0.050) = 3
    [0.050, 0.075) = 0
    [0.075, 0.100) = 0
    [0.100, 0.125) = 0
    [0.125, 0.150) = 0
    [0.150, 0.175) = 0
    [0.175, 0.200) = 0
    [0.200, 0.225) = 0
    [0.225, 0.250) = 0
    [0.250, 0.275) = 0
    [0.275, 0.300) = 0
    [0.300, 0.325) = 1
    [0.325, 0.350) = 0
```

```
    [0.350, 0.375) = 1

  Percentiles, ms/op:
      p(0.0000) =        ≈ 0 ms/op
     p(50.0000) =     ≈ 10⁻⁴ ms/op
     p(90.0000) =     ≈ 10⁻⁴ ms/op
     p(95.0000) =     ≈ 10⁻⁴ ms/op
     p(99.0000) =     ≈ 10⁻⁴ ms/op
     p(99.9000) =     ≈ 10⁻⁴ ms/op
     p(99.9900) =      0.008 ms/op
     p(99.9990) =      0.150 ms/op
     p(99.9999) =      0.360 ms/op
    p(100.0000) =      0.360 ms/op


# JMH version: 1.32
# VM version: JDK 17.0.8, OpenJDK 64-Bit Server VM, 17
.0.8+7-LTS
# VM invoker: /Users/zuzannafurtak/Library/Java/
JavaVirtualMachines/corretto-17.0.8/Contents/Home/bin/
java
# VM options: -javaagent:/Applications/IntelliJ IDEA.
app/Contents/lib/idea_rt.jar=60774:/Applications/
IntelliJ IDEA.app/Contents/bin -Dfile.encoding=UTF-8
# Blackhole mode: full + dont-inline hint
# Warmup: 5 iterations, 1 s each
# Measurement: 10 iterations, 1 s each
# Timeout: 10 min per iteration
# Threads: 1 thread, will synchronize iterations
# Benchmark mode: Sampling time
# Benchmark: com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices
# Parameters: (n = 20)

# Run progress: 11.11% complete, ETA 00:02:05
# Fork: 1 of 1
# Warmup Iteration   1: ≈ 10⁻⁴ ms/op
# Warmup Iteration   2: ≈ 10⁻⁴ ms/op
# Warmup Iteration   3: ≈ 10⁻⁴ ms/op
# Warmup Iteration   4: ≈ 10⁻⁴ ms/op
# Warmup Iteration   5: ≈ 10⁻⁴ ms/op
```

```
Iteration   1: ≈ 10⁻⁴ ms/op
                 multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.9999: 0.005
 ms/op
                 multiplySparseMatrices·p1.00:   0.008
 ms/op

Iteration   2: ≈ 10⁻⁴ ms/op
                 multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.9999: 0.006
 ms/op
                 multiplySparseMatrices·p1.00:   0.009
 ms/op

Iteration   3: ≈ 10⁻⁴ ms/op
                 multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
```

```
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.9999: 0.003
 ms/op
                 multiplySparseMatrices·p1.00:   0.380
 ms/op

Iteration   4: ≈ 10⁻⁴ ms/op
                 multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.9999: 0.004
 ms/op
                 multiplySparseMatrices·p1.00:   0.297
 ms/op

Iteration   5: ≈ 10⁻⁴ ms/op
                 multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.99:   ≈ 10
```

```
⁻⁴ ms/op
                 multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.9999: 0.001
 ms/op
                 multiplySparseMatrices·p1.00:   0.005
 ms/op

Iteration   6: ≈ 10⁻⁴ ms/op
                 multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.9999: 0.001
 ms/op
                 multiplySparseMatrices·p1.00:   0.005
 ms/op

Iteration   7: ≈ 10⁻⁴ ms/op
                 multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.9999: 0.007
 ms/op
```

```
                  multiplySparseMatrices·p1.00:   0.009
 ms/op

Iteration   8: ≈ 10⁻⁴ ms/op
                  multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                  multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                  multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                  multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                  multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                  multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                  multiplySparseMatrices·p0.9999: 0.002
 ms/op
                  multiplySparseMatrices·p1.00:   0.008
 ms/op

Iteration   9: ≈ 10⁻⁴ ms/op
                  multiplySparseMatrices·p0.00:   ≈ 0
ms/op
                  multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                  multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                  multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                  multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                  multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                  multiplySparseMatrices·p0.9999: 0.004
 ms/op
                  multiplySparseMatrices·p1.00:   0.008
 ms/op

Iteration  10: ≈ 10⁻⁴ ms/op
                  multiplySparseMatrices·p0.00:   ≈ 0
```

```
ms/op
                 multiplySparseMatrices·p0.50:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.90:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.95:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.99:   ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.999:  ≈ 10
⁻⁴ ms/op
                 multiplySparseMatrices·p0.9999: 0.006
 ms/op
                 multiplySparseMatrices·p1.00:   0.010
 ms/op



Result "com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices":
  N = 254763
  mean =     ≈ 10⁻⁴ ±(99.9%) 0.001 ms/op

  Histogram, ms/op:
    [0.000, 0.025) = 254761
    [0.025, 0.050) = 0
    [0.050, 0.075) = 0
    [0.075, 0.100) = 0
    [0.100, 0.125) = 0
    [0.125, 0.150) = 0
    [0.150, 0.175) = 0
    [0.175, 0.200) = 0
    [0.200, 0.225) = 0
    [0.225, 0.250) = 0
    [0.250, 0.275) = 0
    [0.275, 0.300) = 1
    [0.300, 0.325) = 0
    [0.325, 0.350) = 0
    [0.350, 0.375) = 0

  Percentiles, ms/op:
```

```
       p(0.0000) =        ≈ 0 ms/op
      p(50.0000) =     ≈ 10⁻⁴ ms/op
      p(90.0000) =     ≈ 10⁻⁴ ms/op
      p(95.0000) =     ≈ 10⁻⁴ ms/op
      p(99.0000) =     ≈ 10⁻⁴ ms/op
      p(99.9000) =     ≈ 10⁻⁴ ms/op
      p(99.9900) =      0.005 ms/op
      p(99.9990) =      0.140 ms/op
      p(99.9999) =      0.380 ms/op
     p(100.0000) =      0.380 ms/op


# JMH version: 1.32
# VM version: JDK 17.0.8, OpenJDK 64-Bit Server VM, 17
.0.8+7-LTS
# VM invoker: /Users/zuzannafurtak/Library/Java/
JavaVirtualMachines/corretto-17.0.8/Contents/Home/bin/
java
# VM options: -javaagent:/Applications/IntelliJ IDEA.
app/Contents/lib/idea_rt.jar=60774:/Applications/
IntelliJ IDEA.app/Contents/bin -Dfile.encoding=UTF-8
# Blackhole mode: full + dont-inline hint
# Warmup: 5 iterations, 1 s each
# Measurement: 10 iterations, 1 s each
# Timeout: 10 min per iteration
# Threads: 1 thread, will synchronize iterations
# Benchmark mode: Sampling time
# Benchmark: com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices
# Parameters: (n = 50)

# Run progress: 22.22% complete, ETA 00:01:49
# Fork: 1 of 1
# Warmup Iteration   1: 0.001 ±(99.9%) 0.001 ms/op
# Warmup Iteration   2: 0.001 ±(99.9%) 0.001 ms/op
# Warmup Iteration   3: 0.001 ±(99.9%) 0.001 ms/op
# Warmup Iteration   4: 0.001 ±(99.9%) 0.001 ms/op
# Warmup Iteration   5: 0.001 ±(99.9%) 0.001 ms/op
Iteration   1: 0.001 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.001
 ms/op
```

```
                  multiplySparseMatrices·p0.50:   0.001
 ms/op
                  multiplySparseMatrices·p0.90:   0.001
 ms/op
                  multiplySparseMatrices·p0.95:   0.001
 ms/op
                  multiplySparseMatrices·p0.99:   0.001
 ms/op
                  multiplySparseMatrices·p0.999:  0.006
 ms/op
                  multiplySparseMatrices·p0.9999: 0.247
 ms/op
                  multiplySparseMatrices·p1.00:   0.334
 ms/op

Iteration   2: 0.001 ±(99.9%) 0.001 ms/op
                  multiplySparseMatrices·p0.00:   0.001
 ms/op
                  multiplySparseMatrices·p0.50:   0.001
 ms/op
                  multiplySparseMatrices·p0.90:   0.001
 ms/op
                  multiplySparseMatrices·p0.95:   0.001
 ms/op
                  multiplySparseMatrices·p0.99:   0.001
 ms/op
                  multiplySparseMatrices·p0.999:  0.005
 ms/op
                  multiplySparseMatrices·p0.9999: 0.013
 ms/op
                  multiplySparseMatrices·p1.00:   0.289
 ms/op

Iteration   3: 0.001 ±(99.9%) 0.001 ms/op
                  multiplySparseMatrices·p0.00:   0.001
 ms/op
                  multiplySparseMatrices·p0.50:   0.001
 ms/op
                  multiplySparseMatrices·p0.90:   0.001
 ms/op
                  multiplySparseMatrices·p0.95:   0.001
```

```
 ms/op
                 multiplySparseMatrices·p0.99:   0.001
 ms/op
                 multiplySparseMatrices·p0.999:  0.006
 ms/op
                 multiplySparseMatrices·p0.9999: 0.027
 ms/op
                 multiplySparseMatrices·p1.00:   0.032
 ms/op

Iteration   4: 0.001 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.001
 ms/op
                 multiplySparseMatrices·p0.50:   0.001
 ms/op
                 multiplySparseMatrices·p0.90:   0.001
 ms/op
                 multiplySparseMatrices·p0.95:   0.001
 ms/op
                 multiplySparseMatrices·p0.99:   0.001
 ms/op
                 multiplySparseMatrices·p0.999:  0.003
 ms/op
                 multiplySparseMatrices·p0.9999: 0.011
 ms/op
                 multiplySparseMatrices·p1.00:   0.303
 ms/op

Iteration   5: 0.001 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.001
 ms/op
                 multiplySparseMatrices·p0.50:   0.001
 ms/op
                 multiplySparseMatrices·p0.90:   0.001
 ms/op
                 multiplySparseMatrices·p0.95:   0.001
 ms/op
                 multiplySparseMatrices·p0.99:   0.001
 ms/op
                 multiplySparseMatrices·p0.999:  0.006
 ms/op
```

```
                  multiplySparseMatrices·p0.9999: 0.014
 ms/op
                  multiplySparseMatrices·p1.00:   0.301
 ms/op

Iteration   6: 0.001 ±(99.9%) 0.001 ms/op
                  multiplySparseMatrices·p0.00:   0.001
 ms/op
                  multiplySparseMatrices·p0.50:   0.001
 ms/op
                  multiplySparseMatrices·p0.90:   0.001
 ms/op
                  multiplySparseMatrices·p0.95:   0.001
 ms/op
                  multiplySparseMatrices·p0.99:   0.001
 ms/op
                  multiplySparseMatrices·p0.999:  0.005
 ms/op
                  multiplySparseMatrices·p0.9999: 0.013
 ms/op
                  multiplySparseMatrices·p1.00:   0.289
 ms/op

Iteration   7: 0.001 ±(99.9%) 0.001 ms/op
                  multiplySparseMatrices·p0.00:   0.001
 ms/op
                  multiplySparseMatrices·p0.50:   0.001
 ms/op
                  multiplySparseMatrices·p0.90:   0.001
 ms/op
                  multiplySparseMatrices·p0.95:   0.001
 ms/op
                  multiplySparseMatrices·p0.99:   0.001
 ms/op
                  multiplySparseMatrices·p0.999:  0.005
 ms/op
                  multiplySparseMatrices·p0.9999: 0.014
 ms/op
                  multiplySparseMatrices·p1.00:   0.323
 ms/op
```

```
Iteration   8: 0.001 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.001
 ms/op
                 multiplySparseMatrices·p0.50:   0.001
 ms/op
                 multiplySparseMatrices·p0.90:   0.001
 ms/op
                 multiplySparseMatrices·p0.95:   0.001
 ms/op
                 multiplySparseMatrices·p0.99:   0.001
 ms/op
                 multiplySparseMatrices·p0.999:  0.006
 ms/op
                 multiplySparseMatrices·p0.9999: 0.014
 ms/op
                 multiplySparseMatrices·p1.00:   0.349
 ms/op

Iteration   9: 0.001 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.001
 ms/op
                 multiplySparseMatrices·p0.50:   0.001
 ms/op
                 multiplySparseMatrices·p0.90:   0.001
 ms/op
                 multiplySparseMatrices·p0.95:   0.001
 ms/op
                 multiplySparseMatrices·p0.99:   0.001
 ms/op
                 multiplySparseMatrices·p0.999:  0.006
 ms/op
                 multiplySparseMatrices·p0.9999: 0.243
 ms/op
                 multiplySparseMatrices·p1.00:   0.312
 ms/op

Iteration  10: 0.001 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.001
 ms/op
                 multiplySparseMatrices·p0.50:   0.001
 ms/op
```

```
                    multiplySparseMatrices·p0.90:   0.001
 ms/op
                    multiplySparseMatrices·p0.95:   0.001
 ms/op
                    multiplySparseMatrices·p0.99:   0.001
 ms/op
                    multiplySparseMatrices·p0.999:  0.004
 ms/op
                    multiplySparseMatrices·p0.9999: 0.231
 ms/op
                    multiplySparseMatrices·p1.00:   0.319
 ms/op



Result "com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices":
  N = 220059
  mean =      0.001 ±(99.9%) 0.001 ms/op

  Histogram, ms/op:
    [0.000, 0.025) = 220045
    [0.025, 0.050) = 2
    [0.050, 0.075) = 0
    [0.075, 0.100) = 0
    [0.100, 0.125) = 0
    [0.125, 0.150) = 0
    [0.150, 0.175) = 0
    [0.175, 0.200) = 0
    [0.200, 0.225) = 0
    [0.225, 0.250) = 0
    [0.250, 0.275) = 0
    [0.275, 0.300) = 3
    [0.300, 0.325) = 7
    [0.325, 0.350) = 2
    [0.350, 0.375) = 0

  Percentiles, ms/op:
      p(0.0000) =      0.001 ms/op
     p(50.0000) =      0.001 ms/op
     p(90.0000) =      0.001 ms/op
```

```
     p(95.0000) =      0.001 ms/op
     p(99.0000) =      0.001 ms/op
     p(99.9000) =      0.005 ms/op
     p(99.9900) =      0.013 ms/op
     p(99.9990) =      0.332 ms/op
     p(99.9999) =      0.349 ms/op
    p(100.0000) =      0.349 ms/op


# JMH version: 1.32
# VM version: JDK 17.0.8, OpenJDK 64-Bit Server VM, 17
.0.8+7-LTS
# VM invoker: /Users/zuzannafurtak/Library/Java/
JavaVirtualMachines/corretto-17.0.8/Contents/Home/bin/
java
# VM options: -javaagent:/Applications/IntelliJ IDEA.
app/Contents/lib/idea_rt.jar=60774:/Applications/
IntelliJ IDEA.app/Contents/bin -Dfile.encoding=UTF-8
# Blackhole mode: full + dont-inline hint
# Warmup: 5 iterations, 1 s each
# Measurement: 10 iterations, 1 s each
# Timeout: 10 min per iteration
# Threads: 1 thread, will synchronize iterations
# Benchmark mode: Sampling time
# Benchmark: com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices
# Parameters: (n = 100)

# Run progress: 33.33% complete, ETA 00:01:33
# Fork: 1 of 1
# Warmup Iteration   1: 0.004 ±(99.9%) 0.001 ms/op
# Warmup Iteration   2: 0.004 ±(99.9%) 0.001 ms/op
# Warmup Iteration   3: 0.004 ±(99.9%) 0.001 ms/op
# Warmup Iteration   4: 0.004 ±(99.9%) 0.001 ms/op
# Warmup Iteration   5: 0.005 ±(99.9%) 0.001 ms/op
Iteration   1: 0.004 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.004
 ms/op
                 multiplySparseMatrices·p0.50:   0.004
 ms/op
                 multiplySparseMatrices·p0.90:   0.006
```

```
 ms/op
                 multiplySparseMatrices·p0.95:   0.006
 ms/op
                 multiplySparseMatrices·p0.99:   0.006
 ms/op
                 multiplySparseMatrices·p0.999:  0.013
 ms/op
                 multiplySparseMatrices·p0.9999: 0.070
 ms/op
                 multiplySparseMatrices·p1.00:   0.348
 ms/op

Iteration   2: 0.005 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.004
 ms/op
                 multiplySparseMatrices·p0.50:   0.004
 ms/op
                 multiplySparseMatrices·p0.90:   0.006
 ms/op
                 multiplySparseMatrices·p0.95:   0.006
 ms/op
                 multiplySparseMatrices·p0.99:   0.006
 ms/op
                 multiplySparseMatrices·p0.999:  0.013
 ms/op
                 multiplySparseMatrices·p0.9999: 0.374
 ms/op
                 multiplySparseMatrices·p1.00:   0.418
 ms/op

Iteration   3: 0.005 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.004
 ms/op
                 multiplySparseMatrices·p0.50:   0.004
 ms/op
                 multiplySparseMatrices·p0.90:   0.006
 ms/op
                 multiplySparseMatrices·p0.95:   0.006
 ms/op
                 multiplySparseMatrices·p0.99:   0.006
 ms/op
```

```
                  multiplySparseMatrices·p0.999:  0.013
 ms/op
                  multiplySparseMatrices·p0.9999: 0.091
 ms/op
                  multiplySparseMatrices·p1.00:   0.385
 ms/op

Iteration   4: 0.005 ±(99.9%) 0.001 ms/op
                  multiplySparseMatrices·p0.00:   0.003
 ms/op
                  multiplySparseMatrices·p0.50:   0.004
 ms/op
                  multiplySparseMatrices·p0.90:   0.006
 ms/op
                  multiplySparseMatrices·p0.95:   0.006
 ms/op
                  multiplySparseMatrices·p0.99:   0.006
 ms/op
                  multiplySparseMatrices·p0.999:  0.013
 ms/op
                  multiplySparseMatrices·p0.9999: 0.334
 ms/op
                  multiplySparseMatrices·p1.00:   0.370
 ms/op

Iteration   5: 0.004 ±(99.9%) 0.001 ms/op
                  multiplySparseMatrices·p0.00:   0.003
 ms/op
                  multiplySparseMatrices·p0.50:   0.004
 ms/op
                  multiplySparseMatrices·p0.90:   0.006
 ms/op
                  multiplySparseMatrices·p0.95:   0.006
 ms/op
                  multiplySparseMatrices·p0.99:   0.006
 ms/op
                  multiplySparseMatrices·p0.999:  0.013
 ms/op
                  multiplySparseMatrices·p0.9999: 0.351
 ms/op
                  multiplySparseMatrices·p1.00:   0.381
```

```
 ms/op

Iteration   6: 0.004 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.003
 ms/op
                 multiplySparseMatrices·p0.50:   0.004
 ms/op
                 multiplySparseMatrices·p0.90:   0.006
 ms/op
                 multiplySparseMatrices·p0.95:   0.006
 ms/op
                 multiplySparseMatrices·p0.99:   0.006
 ms/op
                 multiplySparseMatrices·p0.999:  0.014
 ms/op
                 multiplySparseMatrices·p0.9999: 0.019
 ms/op
                 multiplySparseMatrices·p1.00:   0.351
 ms/op

Iteration   7: 0.005 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.003
 ms/op
                 multiplySparseMatrices·p0.50:   0.004
 ms/op
                 multiplySparseMatrices·p0.90:   0.006
 ms/op
                 multiplySparseMatrices·p0.95:   0.006
 ms/op
                 multiplySparseMatrices·p0.99:   0.006
 ms/op
                 multiplySparseMatrices·p0.999:  0.014
 ms/op
                 multiplySparseMatrices·p0.9999: 0.336
 ms/op
                 multiplySparseMatrices·p1.00:   0.379
 ms/op

Iteration   8: 0.004 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.003
 ms/op
```

```
                  multiplySparseMatrices·p0.50:   0.004
 ms/op
                  multiplySparseMatrices·p0.90:   0.006
 ms/op
                  multiplySparseMatrices·p0.95:   0.006
 ms/op
                  multiplySparseMatrices·p0.99:   0.006
 ms/op
                  multiplySparseMatrices·p0.999:  0.013
 ms/op
                  multiplySparseMatrices·p0.9999: 0.076
 ms/op
                  multiplySparseMatrices·p1.00:   0.359
 ms/op

Iteration   9: 0.004 ±(99.9%) 0.001 ms/op
                  multiplySparseMatrices·p0.00:   0.004
 ms/op
                  multiplySparseMatrices·p0.50:   0.004
 ms/op
                  multiplySparseMatrices·p0.90:   0.005
 ms/op
                  multiplySparseMatrices·p0.95:   0.006
 ms/op
                  multiplySparseMatrices·p0.99:   0.006
 ms/op
                  multiplySparseMatrices·p0.999:  0.013
 ms/op
                  multiplySparseMatrices·p0.9999: 0.335
 ms/op
                  multiplySparseMatrices·p1.00:   0.353
 ms/op

Iteration  10: 0.004 ±(99.9%) 0.001 ms/op
                  multiplySparseMatrices·p0.00:   0.004
 ms/op
                  multiplySparseMatrices·p0.50:   0.004
 ms/op
                  multiplySparseMatrices·p0.90:   0.006
 ms/op
                  multiplySparseMatrices·p0.95:   0.006
```

```
 ms/op
                 multiplySparseMatrices·p0.99:   0.006
 ms/op
                 multiplySparseMatrices·p0.999:  0.013
 ms/op
                 multiplySparseMatrices·p0.9999: 0.121
 ms/op
                 multiplySparseMatrices·p1.00:   0.416
 ms/op



Result "com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices":
  N = 281981
  mean =      0.004 ±(99.9%) 0.001 ms/op

  Histogram, ms/op:
    [0.000, 0.050) = 281952
    [0.050, 0.100) = 3
    [0.100, 0.150) = 0
    [0.150, 0.200) = 0
    [0.200, 0.250) = 0
    [0.250, 0.300) = 0
    [0.300, 0.350) = 10
    [0.350, 0.400) = 14
    [0.400, 0.450) = 2

  Percentiles, ms/op:
      p(0.0000) =      0.003 ms/op
     p(50.0000) =      0.004 ms/op
     p(90.0000) =      0.006 ms/op
     p(95.0000) =      0.006 ms/op
     p(99.0000) =      0.006 ms/op
     p(99.9000) =      0.013 ms/op
     p(99.9900) =      0.069 ms/op
     p(99.9990) =      0.391 ms/op
     p(99.9999) =      0.418 ms/op
    p(100.0000) =      0.418 ms/op
```

```
# JMH version: 1.32
# VM version: JDK 17.0.8, OpenJDK 64-Bit Server VM, 17
.0.8+7-LTS
# VM invoker: /Users/zuzannafurtak/Library/Java/
JavaVirtualMachines/corretto-17.0.8/Contents/Home/bin/
java
# VM options: -javaagent:/Applications/IntelliJ IDEA.
app/Contents/lib/idea_rt.jar=60774:/Applications/
IntelliJ IDEA.app/Contents/bin -Dfile.encoding=UTF-8
# Blackhole mode: full + dont-inline hint
# Warmup: 5 iterations, 1 s each
# Measurement: 10 iterations, 1 s each
# Timeout: 10 min per iteration
# Threads: 1 thread, will synchronize iterations
# Benchmark mode: Sampling time
# Benchmark: com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices
# Parameters: (n = 200)

# Run progress: 44.44% complete, ETA 00:01:18
# Fork: 1 of 1
# Warmup Iteration   1: 0.055 ±(99.9%) 0.001 ms/op
# Warmup Iteration   2: 0.053 ±(99.9%) 0.001 ms/op
# Warmup Iteration   3: 0.052 ±(99.9%) 0.001 ms/op
# Warmup Iteration   4: 0.050 ±(99.9%) 0.001 ms/op
# Warmup Iteration   5: 0.051 ±(99.9%) 0.001 ms/op
Iteration   1: 0.050 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.037
 ms/op
                 multiplySparseMatrices·p0.50:   0.051
 ms/op
                 multiplySparseMatrices·p0.90:   0.058
 ms/op
                 multiplySparseMatrices·p0.95:   0.060
 ms/op
                 multiplySparseMatrices·p0.99:   0.062
 ms/op
                 multiplySparseMatrices·p0.999:  0.068
 ms/op
                 multiplySparseMatrices·p0.9999: 0.525
 ms/op
```

```
                  multiplySparseMatrices·p1.00:   0.627
 ms/op

Iteration   2: 0.050 ±(99.9%) 0.001 ms/op
                  multiplySparseMatrices·p0.00:   0.036
 ms/op
                  multiplySparseMatrices·p0.50:   0.051
 ms/op
                  multiplySparseMatrices·p0.90:   0.058
 ms/op
                  multiplySparseMatrices·p0.95:   0.059
 ms/op
                  multiplySparseMatrices·p0.99:   0.062
 ms/op
                  multiplySparseMatrices·p0.999:  0.121
 ms/op
                  multiplySparseMatrices·p0.9999: 0.628
 ms/op
                  multiplySparseMatrices·p1.00:   0.629
 ms/op

Iteration   3: 0.051 ±(99.9%) 0.001 ms/op
                  multiplySparseMatrices·p0.00:   0.037
 ms/op
                  multiplySparseMatrices·p0.50:   0.051
 ms/op
                  multiplySparseMatrices·p0.90:   0.058
 ms/op
                  multiplySparseMatrices·p0.95:   0.060
 ms/op
                  multiplySparseMatrices·p0.99:   0.063
 ms/op
                  multiplySparseMatrices·p0.999:  0.380
 ms/op
                  multiplySparseMatrices·p0.9999: 1.086
 ms/op
                  multiplySparseMatrices·p1.00:   1.288
 ms/op

Iteration   4: 0.050 ±(99.9%) 0.001 ms/op
                  multiplySparseMatrices·p0.00:   0.036
```

```
 ms/op
                 multiplySparseMatrices·p0.50:   0.051
 ms/op
                 multiplySparseMatrices·p0.90:   0.058
 ms/op
                 multiplySparseMatrices·p0.95:   0.059
 ms/op
                 multiplySparseMatrices·p0.99:   0.062
 ms/op
                 multiplySparseMatrices·p0.999:  0.084
 ms/op
                 multiplySparseMatrices·p0.9999: 0.482
 ms/op
                 multiplySparseMatrices·p1.00:   0.482
 ms/op

Iteration   5: 0.050 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.036
 ms/op
                 multiplySparseMatrices·p0.50:   0.050
 ms/op
                 multiplySparseMatrices·p0.90:   0.058
 ms/op
                 multiplySparseMatrices·p0.95:   0.059
 ms/op
                 multiplySparseMatrices·p0.99:   0.062
 ms/op
                 multiplySparseMatrices·p0.999:  0.070
 ms/op
                 multiplySparseMatrices·p0.9999: 0.496
 ms/op
                 multiplySparseMatrices·p1.00:   0.496
 ms/op

Iteration   6: 0.050 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.036
 ms/op
                 multiplySparseMatrices·p0.50:   0.050
 ms/op
                 multiplySparseMatrices·p0.90:   0.058
 ms/op
```

```
                  multiplySparseMatrices·p0.95:   0.059
 ms/op
                  multiplySparseMatrices·p0.99:   0.062
 ms/op
                  multiplySparseMatrices·p0.999:  0.077
 ms/op
                  multiplySparseMatrices·p0.9999: 0.541
 ms/op
                  multiplySparseMatrices·p1.00:   0.542
 ms/op

Iteration   7: 0.050 ±(99.9%) 0.001 ms/op
                  multiplySparseMatrices·p0.00:   0.036
 ms/op
                  multiplySparseMatrices·p0.50:   0.050
 ms/op
                  multiplySparseMatrices·p0.90:   0.058
 ms/op
                  multiplySparseMatrices·p0.95:   0.059
 ms/op
                  multiplySparseMatrices·p0.99:   0.062
 ms/op
                  multiplySparseMatrices·p0.999:  0.084
 ms/op
                  multiplySparseMatrices·p0.9999: 0.488
 ms/op
                  multiplySparseMatrices·p1.00:   0.488
 ms/op

Iteration   8: 0.050 ±(99.9%) 0.001 ms/op
                  multiplySparseMatrices·p0.00:   0.036
 ms/op
                  multiplySparseMatrices·p0.50:   0.050
 ms/op
                  multiplySparseMatrices·p0.90:   0.058
 ms/op
                  multiplySparseMatrices·p0.95:   0.060
 ms/op
                  multiplySparseMatrices·p0.99:   0.063
 ms/op
                  multiplySparseMatrices·p0.999:  0.114
```

```
 ms/op
                 multiplySparseMatrices·p0.9999: 0.506
 ms/op
                 multiplySparseMatrices·p1.00:   0.506
 ms/op

Iteration   9: 0.050 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.036
 ms/op
                 multiplySparseMatrices·p0.50:   0.051
 ms/op
                 multiplySparseMatrices·p0.90:   0.058
 ms/op
                 multiplySparseMatrices·p0.95:   0.060
 ms/op
                 multiplySparseMatrices·p0.99:   0.064
 ms/op
                 multiplySparseMatrices·p0.999:  0.101
 ms/op
                 multiplySparseMatrices·p0.9999: 0.545
 ms/op
                 multiplySparseMatrices·p1.00:   0.545
 ms/op

Iteration  10: 0.050 ±(99.9%) 0.001 ms/op
                 multiplySparseMatrices·p0.00:   0.037
 ms/op
                 multiplySparseMatrices·p0.50:   0.051
 ms/op
                 multiplySparseMatrices·p0.90:   0.058
 ms/op
                 multiplySparseMatrices·p0.95:   0.060
 ms/op
                 multiplySparseMatrices·p0.99:   0.062
 ms/op
                 multiplySparseMatrices·p0.999:  0.144
 ms/op
                 multiplySparseMatrices·p0.9999: 0.524
 ms/op
                 multiplySparseMatrices·p1.00:   0.524
 ms/op
```

```
Result "com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices":
  N = 119832
  mean =      0.050 ±(99.9%) 0.001 ms/op

  Histogram, ms/op:
    [0.000, 0.125) = 119697
    [0.125, 0.250) = 25
    [0.250, 0.375) = 29
    [0.375, 0.500) = 69
    [0.500, 0.625) = 7
    [0.625, 0.750) = 2
    [0.750, 0.875) = 0
    [0.875, 1.000) = 1
    [1.000, 1.125) = 1
    [1.125, 1.250) = 0
    [1.250, 1.375) = 1
    [1.375, 1.500) = 0
    [1.500, 1.625) = 0
    [1.625, 1.750) = 0
    [1.750, 1.875) = 0

  Percentiles, ms/op:
      p(0.0000) =      0.036 ms/op
     p(50.0000) =      0.051 ms/op
     p(90.0000) =      0.058 ms/op
     p(95.0000) =      0.059 ms/op
     p(99.0000) =      0.062 ms/op
     p(99.9000) =      0.189 ms/op
     p(99.9900) =      0.507 ms/op
     p(99.9990) =      1.247 ms/op
     p(99.9999) =      1.288 ms/op
    p(100.0000) =      1.288 ms/op


# JMH version: 1.32
# VM version: JDK 17.0.8, OpenJDK 64-Bit Server VM, 17
.0.8+7-LTS
```

```
# VM invoker: /Users/zuzannafurtak/Library/Java/
JavaVirtualMachines/corretto-17.0.8/Contents/Home/bin/
java
# VM options: -javaagent:/Applications/IntelliJ IDEA.
app/Contents/lib/idea_rt.jar=60774:/Applications/
IntelliJ IDEA.app/Contents/bin -Dfile.encoding=UTF-8
# Blackhole mode: full + dont-inline hint
# Warmup: 5 iterations, 1 s each
# Measurement: 10 iterations, 1 s each
# Timeout: 10 min per iteration
# Threads: 1 thread, will synchronize iterations
# Benchmark mode: Sampling time
# Benchmark: com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices
# Parameters: (n = 500)

# Run progress: 55.56% complete, ETA 00:01:02
# Fork: 1 of 1
# Warmup Iteration   1: 4.097 ±(99.9%) 0.104 ms/op
# Warmup Iteration   2: 3.977 ±(99.9%) 0.030 ms/op
# Warmup Iteration   3: 3.897 ±(99.9%) 0.023 ms/op
# Warmup Iteration   4: 4.047 ±(99.9%) 0.053 ms/op
# Warmup Iteration   5: 4.018 ±(99.9%) 0.023 ms/op
Iteration   1: 4.423 ±(99.9%) 0.375 ms/op
                 multiplySparseMatrices·p0.00:   3.871
 ms/op
                 multiplySparseMatrices·p0.50:   4.010
 ms/op
                 multiplySparseMatrices·p0.90:   4.578
 ms/op
                 multiplySparseMatrices·p0.95:   6.088
 ms/op
                 multiplySparseMatrices·p0.99:   13.
913 ms/op
                 multiplySparseMatrices·p0.999:  21.
398 ms/op
                 multiplySparseMatrices·p0.9999: 21.
398 ms/op
                 multiplySparseMatrices·p1.00:   21.
398 ms/op
```

```
Iteration   2: 4.065 ±(99.9%) 0.116 ms/op
                 multiplySparseMatrices·p0.00:   3.871
 ms/op
                 multiplySparseMatrices·p0.50:   3.953
 ms/op
                 multiplySparseMatrices·p0.90:   4.268
 ms/op
                 multiplySparseMatrices·p0.95:   4.437
 ms/op
                 multiplySparseMatrices·p0.99:   6.967
 ms/op
                 multiplySparseMatrices·p0.999:  10.
830 ms/op
                 multiplySparseMatrices·p0.9999: 10.
830 ms/op
                 multiplySparseMatrices·p1.00:   10.
830 ms/op

Iteration   3: 4.099 ±(99.9%) 0.124 ms/op
                 multiplySparseMatrices·p0.00:   3.887
 ms/op
                 multiplySparseMatrices·p0.50:   4.002
 ms/op
                 multiplySparseMatrices·p0.90:   4.276
 ms/op
                 multiplySparseMatrices·p0.95:   4.415
 ms/op
                 multiplySparseMatrices·p0.99:   5.344
 ms/op
                 multiplySparseMatrices·p0.999:  12.
763 ms/op
                 multiplySparseMatrices·p0.9999: 12.
763 ms/op
                 multiplySparseMatrices·p1.00:   12.
763 ms/op

Iteration   4: 3.943 ±(99.9%) 0.021 ms/op
                 multiplySparseMatrices·p0.00:   3.834
 ms/op
                 multiplySparseMatrices·p0.50:   3.908
 ms/op
```

```
                  multiplySparseMatrices·p0.90:   4.055
 ms/op
                  multiplySparseMatrices·p0.95:   4.108
 ms/op
                  multiplySparseMatrices·p0.99:   4.414
 ms/op
                  multiplySparseMatrices·p0.999:  4.735
 ms/op
                  multiplySparseMatrices·p0.9999: 4.735
 ms/op
                  multiplySparseMatrices·p1.00:   4.735
 ms/op

Iteration   5: 3.917 ±(99.9%) 0.022 ms/op
                  multiplySparseMatrices·p0.00:   3.801
 ms/op
                  multiplySparseMatrices·p0.50:   3.895
 ms/op
                  multiplySparseMatrices·p0.90:   4.039
 ms/op
                  multiplySparseMatrices·p0.95:   4.071
 ms/op
                  multiplySparseMatrices·p0.99:   4.296
 ms/op
                  multiplySparseMatrices·p0.999:  4.776
 ms/op
                  multiplySparseMatrices·p0.9999: 4.776
 ms/op
                  multiplySparseMatrices·p1.00:   4.776
 ms/op

Iteration   6: 3.896 ±(99.9%) 0.019 ms/op
                  multiplySparseMatrices·p0.00:   3.793
 ms/op
                  multiplySparseMatrices·p0.50:   3.895
 ms/op
                  multiplySparseMatrices·p0.90:   4.002
 ms/op
                  multiplySparseMatrices·p0.95:   4.022
 ms/op
                  multiplySparseMatrices·p0.99:   4.298
```

```
 ms/op
                 multiplySparseMatrices·p0.999:  4.571
 ms/op
                 multiplySparseMatrices·p0.9999: 4.571
 ms/op
                 multiplySparseMatrices·p1.00:   4.571
 ms/op

Iteration   7: 3.937 ±(99.9%) 0.030 ms/op
                 multiplySparseMatrices·p0.00:   3.817
 ms/op
                 multiplySparseMatrices·p0.50:   3.908
 ms/op
                 multiplySparseMatrices·p0.90:   4.022
 ms/op
                 multiplySparseMatrices·p0.95:   4.084
 ms/op
                 multiplySparseMatrices·p0.99:   4.405
 ms/op
                 multiplySparseMatrices·p0.999:  5.784
 ms/op
                 multiplySparseMatrices·p0.9999: 5.784
 ms/op
                 multiplySparseMatrices·p1.00:   5.784
 ms/op

Iteration   8: 4.027 ±(99.9%) 0.097 ms/op
                 multiplySparseMatrices·p0.00:   3.854
 ms/op
                 multiplySparseMatrices·p0.50:   3.928
 ms/op
                 multiplySparseMatrices·p0.90:   4.148
 ms/op
                 multiplySparseMatrices·p0.95:   4.345
 ms/op
                 multiplySparseMatrices·p0.99:   6.745
 ms/op
                 multiplySparseMatrices·p0.999:  9.339
 ms/op
                 multiplySparseMatrices·p0.9999: 9.339
 ms/op
```

```
                  multiplySparseMatrices·p1.00:   9.339
 ms/op

Iteration   9: 3.900 ±(99.9%) 0.018 ms/op
                  multiplySparseMatrices·p0.00:   3.826
 ms/op
                  multiplySparseMatrices·p0.50:   3.879
 ms/op
                  multiplySparseMatrices·p0.90:   4.006
 ms/op
                  multiplySparseMatrices·p0.95:   4.080
 ms/op
                  multiplySparseMatrices·p0.99:   4.296
 ms/op
                  multiplySparseMatrices·p0.999:  4.415
 ms/op
                  multiplySparseMatrices·p0.9999: 4.415
 ms/op
                  multiplySparseMatrices·p1.00:   4.415
 ms/op

Iteration  10: 3.894 ±(99.9%) 0.020 ms/op
                  multiplySparseMatrices·p0.00:   3.809
 ms/op
                  multiplySparseMatrices·p0.50:   3.883
 ms/op
                  multiplySparseMatrices·p0.90:   3.941
 ms/op
                  multiplySparseMatrices·p0.95:   3.991
 ms/op
                  multiplySparseMatrices·p0.99:   4.211
 ms/op
                  multiplySparseMatrices·p0.999:  5.104
 ms/op
                  multiplySparseMatrices·p0.9999: 5.104
 ms/op
                  multiplySparseMatrices·p1.00:   5.104
 ms/op
```

```
Result "com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices":
  N = 2510
  mean =      4.004 ±(99.9%) 0.040 ms/op

  Histogram, ms/op:
    [ 0.000,  2.500) = 0
    [ 2.500,  5.000) = 2483
    [ 5.000,  7.500) = 13
    [ 7.500, 10.000) = 9
    [10.000, 12.500) = 1
    [12.500, 15.000) = 3
    [15.000, 17.500) = 0
    [17.500, 20.000) = 0
    [20.000, 22.500) = 1
    [22.500, 25.000) = 0
    [25.000, 27.500) = 0

  Percentiles, ms/op:
      p(0.0000) =      3.793 ms/op
     p(50.0000) =      3.916 ms/op
     p(90.0000) =      4.129 ms/op
     p(95.0000) =      4.284 ms/op
     p(99.0000) =      5.097 ms/op
     p(99.9000) =     13.807 ms/op
     p(99.9900) =     21.398 ms/op
     p(99.9990) =     21.398 ms/op
     p(99.9999) =     21.398 ms/op
    p(100.0000) =     21.398 ms/op


# JMH version: 1.32
# VM version: JDK 17.0.8, OpenJDK 64-Bit Server VM, 17
.0.8+7-LTS
# VM invoker: /Users/zuzannafurtak/Library/Java/
JavaVirtualMachines/corretto-17.0.8/Contents/Home/bin/
java
# VM options: -javaagent:/Applications/IntelliJ IDEA.
app/Contents/lib/idea_rt.jar=60774:/Applications/
IntelliJ IDEA.app/Contents/bin -Dfile.encoding=UTF-8
# Blackhole mode: full + dont-inline hint
```

```
# Warmup: 5 iterations, 1 s each
# Measurement: 10 iterations, 1 s each
# Timeout: 10 min per iteration
# Threads: 1 thread, will synchronize iterations
# Benchmark mode: Sampling time
# Benchmark: com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices
# Parameters: (n = 1000)

# Run progress: 66.67% complete, ETA 00:00:46
# Fork: 1 of 1
# Warmup Iteration   1: 45.750 ±(99.9%) 2.123 ms/op
# Warmup Iteration   2: 45.890 ±(99.9%) 0.664 ms/op
# Warmup Iteration   3: 45.476 ±(99.9%) 0.482 ms/op
# Warmup Iteration   4: 45.385 ±(99.9%) 0.439 ms/op
# Warmup Iteration   5: 46.498 ±(99.9%) 2.918 ms/op
Iteration   1: 45.462 ±(99.9%) 0.931 ms/op
                 multiplySparseMatrices·p0.00:   44.
827 ms/op
                 multiplySparseMatrices·p0.50:   45.
089 ms/op
                 multiplySparseMatrices·p0.90:   45.
849 ms/op
                 multiplySparseMatrices·p0.95:   49.
703 ms/op
                 multiplySparseMatrices·p0.99:   50.
659 ms/op
                 multiplySparseMatrices·p0.999:  50.
659 ms/op
                 multiplySparseMatrices·p0.9999: 50.
659 ms/op
                 multiplySparseMatrices·p1.00:   50.
659 ms/op

Iteration   2: 45.416 ±(99.9%) 0.517 ms/op
                 multiplySparseMatrices·p0.00:   44.
827 ms/op
                 multiplySparseMatrices·p0.50:   45.
023 ms/op
                 multiplySparseMatrices·p0.90:   46.
557 ms/op
```

```
                 multiplySparseMatrices·p0.95:   47.
081 ms/op
                 multiplySparseMatrices·p0.99:   47.
186 ms/op
                 multiplySparseMatrices·p0.999:  47.
186 ms/op
                 multiplySparseMatrices·p0.9999: 47.
186 ms/op
                 multiplySparseMatrices·p1.00:   47.
186 ms/op

Iteration   3: 45.508 ±(99.9%) 0.507 ms/op
                 multiplySparseMatrices·p0.00:   44.
827 ms/op
                 multiplySparseMatrices·p0.50:   45.
351 ms/op
                 multiplySparseMatrices·p0.90:   46.
321 ms/op
                 multiplySparseMatrices·p0.95:   47.
291 ms/op
                 multiplySparseMatrices·p0.99:   47.
514 ms/op
                 multiplySparseMatrices·p0.999:  47.
514 ms/op
                 multiplySparseMatrices·p0.9999: 47.
514 ms/op
                 multiplySparseMatrices·p1.00:   47.
514 ms/op

Iteration   4: 45.237 ±(99.9%) 0.360 ms/op
                 multiplySparseMatrices·p0.00:   44.
761 ms/op
                 multiplySparseMatrices·p0.50:   45.
089 ms/op
                 multiplySparseMatrices·p0.90:   45.
941 ms/op
                 multiplySparseMatrices·p0.95:   46.
465 ms/op
                 multiplySparseMatrices·p0.99:   46.
596 ms/op
                 multiplySparseMatrices·p0.999:  46.
```

```
596 ms/op
                 multiplySparseMatrices·p0.9999: 46.
596 ms/op
                 multiplySparseMatrices·p1.00:   46.
596 ms/op

Iteration   5: 45.394 ±(99.9%) 0.555 ms/op
                 multiplySparseMatrices·p0.00:   44.
827 ms/op
                 multiplySparseMatrices·p0.50:   45.
023 ms/op
                 multiplySparseMatrices·p0.90:   46.
596 ms/op
                 multiplySparseMatrices·p0.95:   47.
225 ms/op
                 multiplySparseMatrices·p0.99:   47.
317 ms/op
                 multiplySparseMatrices·p0.999:  47.
317 ms/op
                 multiplySparseMatrices·p0.9999: 47.
317 ms/op
                 multiplySparseMatrices·p1.00:   47.
317 ms/op

Iteration   6: 45.177 ±(99.9%) 0.389 ms/op
                 multiplySparseMatrices·p0.00:   44.
761 ms/op
                 multiplySparseMatrices·p0.50:   44.
892 ms/op
                 multiplySparseMatrices·p0.90:   45.
823 ms/op
                 multiplySparseMatrices·p0.95:   46.
557 ms/op
                 multiplySparseMatrices·p0.99:   46.
727 ms/op
                 multiplySparseMatrices·p0.999:  46.
727 ms/op
                 multiplySparseMatrices·p0.9999: 46.
727 ms/op
                 multiplySparseMatrices·p1.00:   46.
727 ms/op
```

```
Iteration   7: 45.288 ±(99.9%) 0.573 ms/op
                 multiplySparseMatrices·p0.00:   44.
761 ms/op
                 multiplySparseMatrices·p0.50:   45.
089 ms/op
                 multiplySparseMatrices·p0.90:   46.
622 ms/op
                 multiplySparseMatrices·p0.95:   47.
514 ms/op
                 multiplySparseMatrices·p0.99:   47.
645 ms/op
                 multiplySparseMatrices·p0.999:  47.
645 ms/op
                 multiplySparseMatrices·p0.9999: 47.
645 ms/op
                 multiplySparseMatrices·p1.00:   47.
645 ms/op

Iteration   8: 45.226 ±(99.9%) 0.417 ms/op
                 multiplySparseMatrices·p0.00:   44.
827 ms/op
                 multiplySparseMatrices·p0.50:   44.
958 ms/op
                 multiplySparseMatrices·p0.90:   46.
006 ms/op
                 multiplySparseMatrices·p0.95:   46.
688 ms/op
                 multiplySparseMatrices·p0.99:   46.
858 ms/op
                 multiplySparseMatrices·p0.999:  46.
858 ms/op
                 multiplySparseMatrices·p0.9999: 46.
858 ms/op
                 multiplySparseMatrices·p1.00:   46.
858 ms/op

Iteration   9: 45.186 ±(99.9%) 0.489 ms/op
                 multiplySparseMatrices·p0.00:   44.
630 ms/op
                 multiplySparseMatrices·p0.50:   44.
```

```
958 ms/op
                 multiplySparseMatrices·p0.90:   46.
386 ms/op
                 multiplySparseMatrices·p0.95:   46.
832 ms/op
                 multiplySparseMatrices·p0.99:   46.
858 ms/op
                 multiplySparseMatrices·p0.999:  46.
858 ms/op
                 multiplySparseMatrices·p0.9999: 46.
858 ms/op
                 multiplySparseMatrices·p1.00:   46.
858 ms/op

Iteration  10: 45.220 ±(99.9%) 0.528 ms/op
                 multiplySparseMatrices·p0.00:   44.
696 ms/op
                 multiplySparseMatrices·p0.50:   44.
892 ms/op
                 multiplySparseMatrices·p0.90:   46.
426 ms/op
                 multiplySparseMatrices·p0.95:   47.
081 ms/op
                 multiplySparseMatrices·p0.99:   47.
186 ms/op
                 multiplySparseMatrices·p0.999:  47.
186 ms/op
                 multiplySparseMatrices·p0.9999: 47.
186 ms/op
                 multiplySparseMatrices·p1.00:   47.
186 ms/op



Result "com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices":
  N = 230
  mean =     45.311 ±(99.9%) 0.151 ms/op

  Histogram, ms/op:
    [44.000, 44.500) = 0
```

```
    [44.500, 45.000) = 107
    [45.000, 45.500) = 62
    [45.500, 46.000) = 36
    [46.000, 46.500) = 10
    [46.500, 47.000) = 9
    [47.000, 47.500) = 3
    [47.500, 48.000) = 2
    [48.000, 48.500) = 0
    [48.500, 49.000) = 0
    [49.000, 49.500) = 0
    [49.500, 50.000) = 0
    [50.000, 50.500) = 0

  Percentiles, ms/op:
      p(0.0000) =     44.630 ms/op
     p(50.0000) =     45.023 ms/op
     p(90.0000) =     46.065 ms/op
     p(95.0000) =     46.727 ms/op
     p(99.0000) =     47.604 ms/op
     p(99.9000) =     50.659 ms/op
     p(99.9900) =     50.659 ms/op
     p(99.9990) =     50.659 ms/op
     p(99.9999) =     50.659 ms/op
    p(100.0000) =     50.659 ms/op


# JMH version: 1.32
# VM version: JDK 17.0.8, OpenJDK 64-Bit Server VM, 17
.0.8+7-LTS
# VM invoker: /Users/zuzannafurtak/Library/Java/
JavaVirtualMachines/corretto-17.0.8/Contents/Home/bin/
java
# VM options: -javaagent:/Applications/IntelliJ IDEA.
app/Contents/lib/idea_rt.jar=60774:/Applications/
IntelliJ IDEA.app/Contents/bin -Dfile.encoding=UTF-8
# Blackhole mode: full + dont-inline hint
# Warmup: 5 iterations, 1 s each
# Measurement: 10 iterations, 1 s each
# Timeout: 10 min per iteration
# Threads: 1 thread, will synchronize iterations
# Benchmark mode: Sampling time
```

```
# Benchmark: com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices
# Parameters: (n = 1500)

# Run progress: 77.78% complete, ETA 00:00:31
# Fork: 1 of 1
# Warmup Iteration   1: 183.501 ±(99.9%) 31.087 ms/op
# Warmup Iteration   2: 184.156 ±(99.9%) 10.268 ms/op
# Warmup Iteration   3: 182.627 ±(99.9%) 7.242 ms/op
# Warmup Iteration   4: 181.273 ±(99.9%) 4.429 ms/op
# Warmup Iteration   5: 182.277 ±(99.9%) 9.870 ms/op
Iteration   1: 179.787 ±(99.9%) 2.606 ms/op
                 multiplySparseMatrices·p0.00:   178.
258 ms/op
                 multiplySparseMatrices·p0.50:   179.
700 ms/op
                 multiplySparseMatrices·p0.90:   180.
879 ms/op
                 multiplySparseMatrices·p0.95:   180.
879 ms/op
                 multiplySparseMatrices·p0.99:   180.
879 ms/op
                 multiplySparseMatrices·p0.999:  180.
879 ms/op
                 multiplySparseMatrices·p0.9999: 180.
879 ms/op
                 multiplySparseMatrices·p1.00:   180.
879 ms/op

Iteration   2: 182.409 ±(99.9%) 15.444 ms/op
                 multiplySparseMatrices·p0.00:   178.
258 ms/op
                 multiplySparseMatrices·p0.50:   180.
879 ms/op
                 multiplySparseMatrices·p0.90:   193.
200 ms/op
                 multiplySparseMatrices·p0.95:   193.
200 ms/op
                 multiplySparseMatrices·p0.99:   193.
200 ms/op
                 multiplySparseMatrices·p0.999:  193.
```

```
200 ms/op
                 multiplySparseMatrices·p0.9999: 193.
200 ms/op
                 multiplySparseMatrices·p1.00:   193.
200 ms/op

Iteration   3: 182.496 ±(99.9%) 12.444 ms/op
                 multiplySparseMatrices·p0.00:   177.
471 ms/op
                 multiplySparseMatrices·p0.50:   181.
404 ms/op
                 multiplySparseMatrices·p0.90:   188.
482 ms/op
                 multiplySparseMatrices·p0.95:   188.
482 ms/op
                 multiplySparseMatrices·p0.99:   188.
482 ms/op
                 multiplySparseMatrices·p0.999:  188.
482 ms/op
                 multiplySparseMatrices·p0.9999: 188.
482 ms/op
                 multiplySparseMatrices·p1.00:   188.
482 ms/op

Iteration   4: 181.841 ±(99.9%) 9.433 ms/op
                 multiplySparseMatrices·p0.00:   179.
044 ms/op
                 multiplySparseMatrices·p0.50:   180.
748 ms/op
                 multiplySparseMatrices·p0.90:   187.
171 ms/op
                 multiplySparseMatrices·p0.95:   187.
171 ms/op
                 multiplySparseMatrices·p0.99:   187.
171 ms/op
                 multiplySparseMatrices·p0.999:  187.
171 ms/op
                 multiplySparseMatrices·p0.9999: 187.
171 ms/op
                 multiplySparseMatrices·p1.00:   187.
171 ms/op
```

```
Iteration   5: 182.059 ±(99.9%) 9.214 ms/op
                 multiplySparseMatrices·p0.00:   179.
306 ms/op
                 multiplySparseMatrices·p0.50:   180.
355 ms/op
                 multiplySparseMatrices·p0.90:   186.
647 ms/op
                 multiplySparseMatrices·p0.95:   186.
647 ms/op
                 multiplySparseMatrices·p0.99:   186.
647 ms/op
                 multiplySparseMatrices·p0.999:  186.
647 ms/op
                 multiplySparseMatrices·p0.9999: 186.
647 ms/op
                 multiplySparseMatrices·p1.00:   186.
647 ms/op

Iteration   6: 180.705 ±(99.9%) 7.663 ms/op
                 multiplySparseMatrices·p0.00:   178.
782 ms/op
                 multiplySparseMatrices·p0.50:   179.
700 ms/op
                 multiplySparseMatrices·p0.90:   186.
122 ms/op
                 multiplySparseMatrices·p0.95:   186.
122 ms/op
                 multiplySparseMatrices·p0.99:   186.
122 ms/op
                 multiplySparseMatrices·p0.999:  186.
122 ms/op
                 multiplySparseMatrices·p0.9999: 186.
122 ms/op
                 multiplySparseMatrices·p1.00:   186.
122 ms/op

Iteration   7: 181.273 ±(99.9%) 9.849 ms/op
                 multiplySparseMatrices·p0.00:   177.
209 ms/op
                 multiplySparseMatrices·p0.50:   180.
```

```
748 ms/op
                 multiplySparseMatrices·p0.90:   186.
384 ms/op
                 multiplySparseMatrices·p0.95:   186.
384 ms/op
                 multiplySparseMatrices·p0.99:   186.
384 ms/op
                 multiplySparseMatrices·p0.999:  186.
384 ms/op
                 multiplySparseMatrices·p0.9999: 186.
384 ms/op
                 multiplySparseMatrices·p1.00:   186.
384 ms/op

Iteration   8: 181.316 ±(99.9%) 8.441 ms/op
                 multiplySparseMatrices·p0.00:   178.
520 ms/op
                 multiplySparseMatrices·p0.50:   180.
879 ms/op
                 multiplySparseMatrices·p0.90:   186.
909 ms/op
                 multiplySparseMatrices·p0.95:   186.
909 ms/op
                 multiplySparseMatrices·p0.99:   186.
909 ms/op
                 multiplySparseMatrices·p0.999:  186.
909 ms/op
                 multiplySparseMatrices·p0.9999: 186.
909 ms/op
                 multiplySparseMatrices·p1.00:   186.
909 ms/op

Iteration   9: 181.054 ±(99.9%) 11.328 ms/op
                 multiplySparseMatrices·p0.00:   177.
209 ms/op
                 multiplySparseMatrices·p0.50:   179.
569 ms/op
                 multiplySparseMatrices·p0.90:   187.
433 ms/op
                 multiplySparseMatrices·p0.95:   187.
433 ms/op
```

```
                 multiplySparseMatrices·p0.99:   187.
433 ms/op
                 multiplySparseMatrices·p0.999:  187.
433 ms/op
                 multiplySparseMatrices·p0.9999: 187.
433 ms/op
                 multiplySparseMatrices·p1.00:   187.
433 ms/op

Iteration  10: 180.486 ±(99.9%) 8.855 ms/op
                 multiplySparseMatrices·p0.00:   177.
996 ms/op
                 multiplySparseMatrices·p0.50:   179.
438 ms/op
                 multiplySparseMatrices·p0.90:   186.
384 ms/op
                 multiplySparseMatrices·p0.95:   186.
384 ms/op
                 multiplySparseMatrices·p0.99:   186.
384 ms/op
                 multiplySparseMatrices·p0.999:  186.
384 ms/op
                 multiplySparseMatrices·p0.9999: 186.
384 ms/op
                 multiplySparseMatrices·p1.00:   186.
384 ms/op



Result "com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices":
  N = 60
  mean =    181.342 ±(99.9%) 1.520 ms/op

  Histogram, ms/op:
    [170.000, 172.500) = 0
    [172.500, 175.000) = 0
    [175.000, 177.500) = 3
    [177.500, 180.000) = 24
    [180.000, 182.500) = 19
    [182.500, 185.000) = 3
```

```
    [185.000, 187.500) = 9
    [187.500, 190.000) = 1
    [190.000, 192.500) = 0
    [192.500, 195.000) = 1
    [195.000, 197.500) = 0

  Percentiles, ms/op:
      p(0.0000) =    177.209 ms/op
     p(50.0000) =    180.224 ms/op
     p(90.0000) =    186.882 ms/op
     p(95.0000) =    187.420 ms/op
     p(99.0000) =    193.200 ms/op
     p(99.9000) =    193.200 ms/op
     p(99.9900) =    193.200 ms/op
     p(99.9990) =    193.200 ms/op
     p(99.9999) =    193.200 ms/op
    p(100.0000) =    193.200 ms/op


# JMH version: 1.32
# VM version: JDK 17.0.8, OpenJDK 64-Bit Server VM, 17
.0.8+7-LTS
# VM invoker: /Users/zuzannafurtak/Library/Java/
JavaVirtualMachines/corretto-17.0.8/Contents/Home/bin/
java
# VM options: -javaagent:/Applications/IntelliJ IDEA.
app/Contents/lib/idea_rt.jar=60774:/Applications/
IntelliJ IDEA.app/Contents/bin -Dfile.encoding=UTF-8
# Blackhole mode: full + dont-inline hint
# Warmup: 5 iterations, 1 s each
# Measurement: 10 iterations, 1 s each
# Timeout: 10 min per iteration
# Threads: 1 thread, will synchronize iterations
# Benchmark mode: Sampling time
# Benchmark: com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices
# Parameters: (n = 2000)

# Run progress: 88.89% complete, ETA 00:00:15
# Fork: 1 of 1
# Warmup Iteration   1: 498.248 ±(99.9%) 595.824 ms/op
```

```
# Warmup Iteration   2: 514.851 ms/op
# Warmup Iteration   3: 508.035 ms/op
# Warmup Iteration   4: 502.530 ms/op
# Warmup Iteration   5: 500.870 ±(99.9%) 77.313 ms/op
Iteration   1: 503.316 ms/op
                 multiplySparseMatrices·p0.00:   495.
976 ms/op
                 multiplySparseMatrices·p0.50:   503.
316 ms/op
                 multiplySparseMatrices·p0.90:   510.
657 ms/op
                 multiplySparseMatrices·p0.95:   510.
657 ms/op
                 multiplySparseMatrices·p0.99:   510.
657 ms/op
                 multiplySparseMatrices·p0.999:  510.
657 ms/op
                 multiplySparseMatrices·p0.9999: 510.
657 ms/op
                 multiplySparseMatrices·p1.00:   510.
657 ms/op

Iteration   2: 509.608 ±(99.9%) 288.856 ms/op
                 multiplySparseMatrices·p0.00:   492.
831 ms/op
                 multiplySparseMatrices·p0.50:   511.
705 ms/op
                 multiplySparseMatrices·p0.90:   524.
288 ms/op
                 multiplySparseMatrices·p0.95:   524.
288 ms/op
                 multiplySparseMatrices·p0.99:   524.
288 ms/op
                 multiplySparseMatrices·p0.999:  524.
288 ms/op
                 multiplySparseMatrices·p0.9999: 524.
288 ms/op
                 multiplySparseMatrices·p1.00:   524.
288 ms/op

Iteration   3: 500.171 ±(99.9%) 177.146 ms/op
```

```
                  multiplySparseMatrices·p0.00:   490.
209 ms/op
                  multiplySparseMatrices·p0.50:   500.
695 ms/op
                  multiplySparseMatrices·p0.90:   509.
608 ms/op
                  multiplySparseMatrices·p0.95:   509.
608 ms/op
                  multiplySparseMatrices·p0.99:   509.
608 ms/op
                  multiplySparseMatrices·p0.999:  509.
608 ms/op
                  multiplySparseMatrices·p0.9999: 509.
608 ms/op
                  multiplySparseMatrices·p1.00:   509.
608 ms/op

Iteration   4: 500.695 ms/op
                  multiplySparseMatrices·p0.00:   493.
879 ms/op
                  multiplySparseMatrices·p0.50:   500.
695 ms/op
                  multiplySparseMatrices·p0.90:   507.
511 ms/op
                  multiplySparseMatrices·p0.95:   507.
511 ms/op
                  multiplySparseMatrices·p0.99:   507.
511 ms/op
                  multiplySparseMatrices·p0.999:  507.
511 ms/op
                  multiplySparseMatrices·p0.9999: 507.
511 ms/op
                  multiplySparseMatrices·p1.00:   507.
511 ms/op

Iteration   5: 506.986 ms/op
                  multiplySparseMatrices·p0.00:   492.
306 ms/op
                  multiplySparseMatrices·p0.50:   506.
986 ms/op
                  multiplySparseMatrices·p0.90:   521.
```

```
667 ms/op
                 multiplySparseMatrices·p0.95:   521.
667 ms/op
                 multiplySparseMatrices·p0.99:   521.
667 ms/op
                 multiplySparseMatrices·p0.999:  521.
667 ms/op
                 multiplySparseMatrices·p0.9999: 521.
667 ms/op
                 multiplySparseMatrices·p1.00:   521.
667 ms/op

Iteration   6: 502.443 ±(99.9%) 88.874 ms/op
                 multiplySparseMatrices·p0.00:   497.
025 ms/op
                 multiplySparseMatrices·p0.50:   503.
841 ms/op
                 multiplySparseMatrices·p0.90:   506.
462 ms/op
                 multiplySparseMatrices·p0.95:   506.
462 ms/op
                 multiplySparseMatrices·p0.99:   506.
462 ms/op
                 multiplySparseMatrices·p0.999:  506.
462 ms/op
                 multiplySparseMatrices·p0.9999: 506.
462 ms/op
                 multiplySparseMatrices·p1.00:   506.
462 ms/op

Iteration   7: 510.919 ms/op
                 multiplySparseMatrices·p0.00:   492.
306 ms/op
                 multiplySparseMatrices·p0.50:   510.
919 ms/op
                 multiplySparseMatrices·p0.90:   529.
531 ms/op
                 multiplySparseMatrices·p0.95:   529.
531 ms/op
                 multiplySparseMatrices·p0.99:   529.
531 ms/op
```

```
                 multiplySparseMatrices·p0.999:  529.
531 ms/op
                 multiplySparseMatrices·p0.9999: 529.
531 ms/op
                 multiplySparseMatrices·p1.00:   529.
531 ms/op

Iteration   8: 503.491 ±(99.9%) 179.540 ms/op
                 multiplySparseMatrices·p0.00:   492.
831 ms/op
                 multiplySparseMatrices·p0.50:   505.
414 ms/op
                 multiplySparseMatrices·p0.90:   512.
229 ms/op
                 multiplySparseMatrices·p0.95:   512.
229 ms/op
                 multiplySparseMatrices·p0.99:   512.
229 ms/op
                 multiplySparseMatrices·p0.999:  512.
229 ms/op
                 multiplySparseMatrices·p0.9999: 512.
229 ms/op
                 multiplySparseMatrices·p1.00:   512.
229 ms/op

Iteration   9: 499.996 ±(99.9%) 182.070 ms/op
                 multiplySparseMatrices·p0.00:   489.
685 ms/op
                 multiplySparseMatrices·p0.50:   500.
695 ms/op
                 multiplySparseMatrices·p0.90:   509.
608 ms/op
                 multiplySparseMatrices·p0.95:   509.
608 ms/op
                 multiplySparseMatrices·p0.99:   509.
608 ms/op
                 multiplySparseMatrices·p0.999:  509.
608 ms/op
                 multiplySparseMatrices·p0.9999: 509.
608 ms/op
                 multiplySparseMatrices·p1.00:   509.
```

```
608 ms/op

Iteration  10: 502.792 ms/op
                 multiplySparseMatrices·p0.00:   501.
219 ms/op
                 multiplySparseMatrices·p0.50:   502.
792 ms/op
                 multiplySparseMatrices·p0.90:   504.
365 ms/op
                 multiplySparseMatrices·p0.95:   504.
365 ms/op
                 multiplySparseMatrices·p0.99:   504.
365 ms/op
                 multiplySparseMatrices·p0.999:  504.
365 ms/op
                 multiplySparseMatrices·p0.9999: 504.
365 ms/op
                 multiplySparseMatrices·p1.00:   504.
365 ms/op



Result "com.matrix.MatrixMultiplicationBenchmark.
multiplySparseMatrices":
  N = 25
  mean =    503.862 ±(99.9%) 8.081 ms/op

  Histogram, ms/op:
    [480.000, 485.000) = 0
    [485.000, 490.000) = 1
    [490.000, 495.000) = 6
    [495.000, 500.000) = 2
    [500.000, 505.000) = 5
    [505.000, 510.000) = 5
    [510.000, 515.000) = 3
    [515.000, 520.000) = 0
    [520.000, 525.000) = 2

  Percentiles, ms/op:
      p(0.0000) =    489.685 ms/op
     p(50.0000) =    503.841 ms/op
```

```
     p(90.0000) =    522.715 ms/op
     p(95.0000) =    527.958 ms/op
     p(99.0000) =    529.531 ms/op
     p(99.9000) =    529.531 ms/op
     p(99.9900) =    529.531 ms/op
     p(99.9990) =    529.531 ms/op
     p(99.9999) =    529.531 ms/op
    p(100.0000) =    529.531 ms/op


# Run complete. Total time: 00:02:27

REMEMBER: The numbers below are just data. To gain
reusable insights, you need to follow up on
why the numbers are the way they are. Use profilers (
see -prof, -lprof), design factorial
experiments, perform baseline and negative tests that
provide experimental control, make sure
the benchmarking environment is safe on JVM/OS/HW
level, ask for reviews from the domain experts.
Do not assume the numbers tell you what you want them
to tell.

Benchmark

                        (n)    Mode     Cnt    Score
    Error  Units
MatrixMultiplicationBenchmark.multiplySparseMatrices
                                    10  sample  258315
   ≈ 10⁻⁴           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.00      10  sample
              ≈ 0           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.50      10  sample
           ≈ 10⁻⁴           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.90      10  sample
           ≈ 10⁻⁴           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.95      10  sample
```

```
            ≈ 10⁻⁴           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.99      10  sample
            ≈ 10⁻⁴           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.999     10  sample
            ≈ 10⁻⁴           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.9999    10  sample
             0.008           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p1.00      10  sample
             0.360           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices
                                   20  sample  254763
   ≈ 10⁻⁴           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.00      20  sample
               ≈ 0           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.50      20  sample
            ≈ 10⁻⁴           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.90      20  sample
            ≈ 10⁻⁴           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.95      20  sample
            ≈ 10⁻⁴           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.99      20  sample
            ≈ 10⁻⁴           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.999     20  sample
            ≈ 10⁻⁴           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.9999    20  sample
             0.005           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p1.00      20  sample
             0.380           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices
```

```
                                    50  sample  220059
    0.001 ±  0.001  ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.00      50  sample
            0.001           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.50      50  sample
            0.001           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.90      50  sample
            0.001           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.95      50  sample
            0.001           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.99      50  sample
            0.001           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.999     50  sample
            0.005           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.9999    50  sample
            0.013           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p1.00      50  sample
            0.349           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices
                                   100  sample  281981
    0.004 ±  0.001  ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.00     100  sample
            0.003           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.50     100  sample
            0.004           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.90     100  sample
            0.006           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.95     100  sample
            0.006           ms/op
```

```
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.99     100  sample
            0.006           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.999    100  sample
            0.013           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.9999   100  sample
            0.069           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p1.00     100  sample
            0.418           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices
                                  200  sample  119832
    0.050 ±  0.001  ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.00     200  sample
            0.036           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.50     200  sample
            0.051           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.90     200  sample
            0.058           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.95     200  sample
            0.059           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.99     200  sample
            0.062           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.999    200  sample
            0.189           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.9999   200  sample
            0.507           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p1.00     200  sample
            1.288           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices
                                  500  sample    2510
```

```
    4.004 ±  0.040  ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.00     500  sample
            3.793           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.50     500  sample
            3.916           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.90     500  sample
            4.129           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.95     500  sample
            4.284           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.99     500  sample
            5.097           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.999    500  sample
           13.807           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.9999   500  sample
           21.398           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p1.00     500  sample
           21.398           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices
                                 1000  sample     230
   45.311 ±  0.151  ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.00    1000  sample
           44.630           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.50    1000  sample
           45.023           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.90    1000  sample
           46.065           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.95    1000  sample
           46.727           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
```

```
multiplySparseMatrices·p0.99    1000  sample
           47.604           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.999   1000  sample
           50.659           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.9999  1000  sample
           50.659           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p1.00    1000  sample
           50.659           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices
                                 1500  sample      60
  181.342 ±  1.520  ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.00    1500  sample
177.209           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.50    1500  sample
180.224           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.90    1500  sample
186.882           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.95    1500  sample
187.420           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.99    1500  sample
193.200           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.999   1500  sample
193.200           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.9999  1500  sample
193.200           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p1.00    1500  sample
193.200           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices
                                 2000  sample      25
  503.862 ±  8.081  ms/op
```

```
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.00    2000  sample
489.685           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.50    2000  sample
503.841           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.90    2000  sample
522.715           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.95    2000  sample
527.958           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.99    2000  sample
529.531           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.999   2000  sample
529.531           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p0.9999  2000  sample
529.531           ms/op
MatrixMultiplicationBenchmark.multiplySparseMatrices:
multiplySparseMatrices·p1.00    2000  sample
529.531           ms/op

Process finished with exit code 0
```