Turbo Charge CPU Utilization in Fork/Join Using the ManagedBlocker
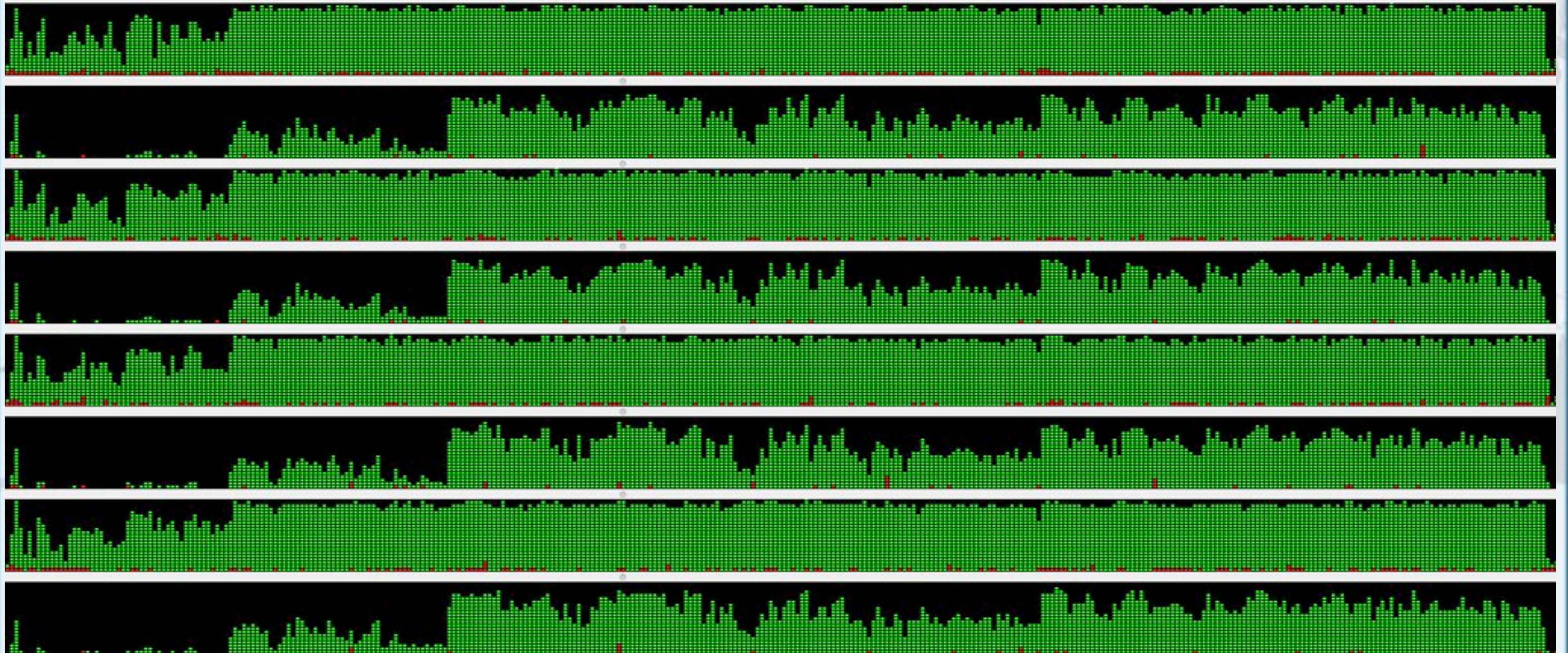
Dr Heinz M. Kabutz

Last Updated 2017-05-15
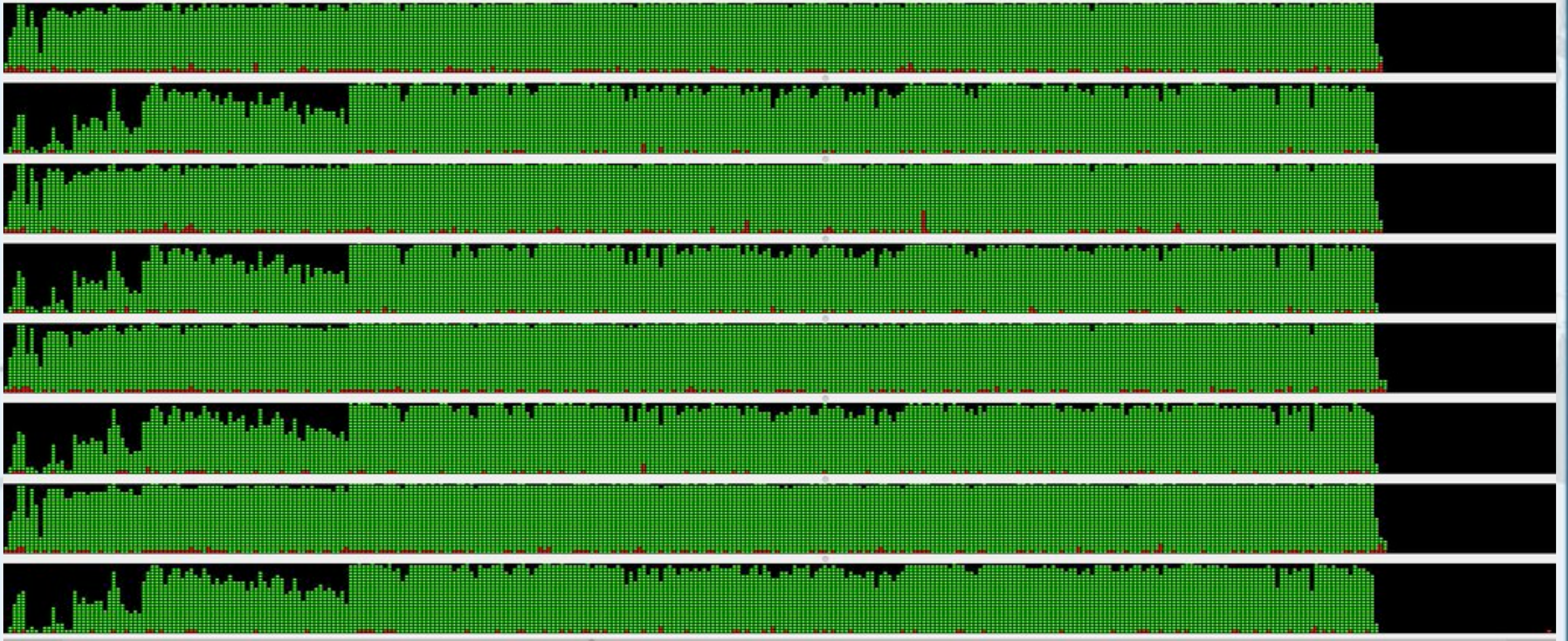
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Regular

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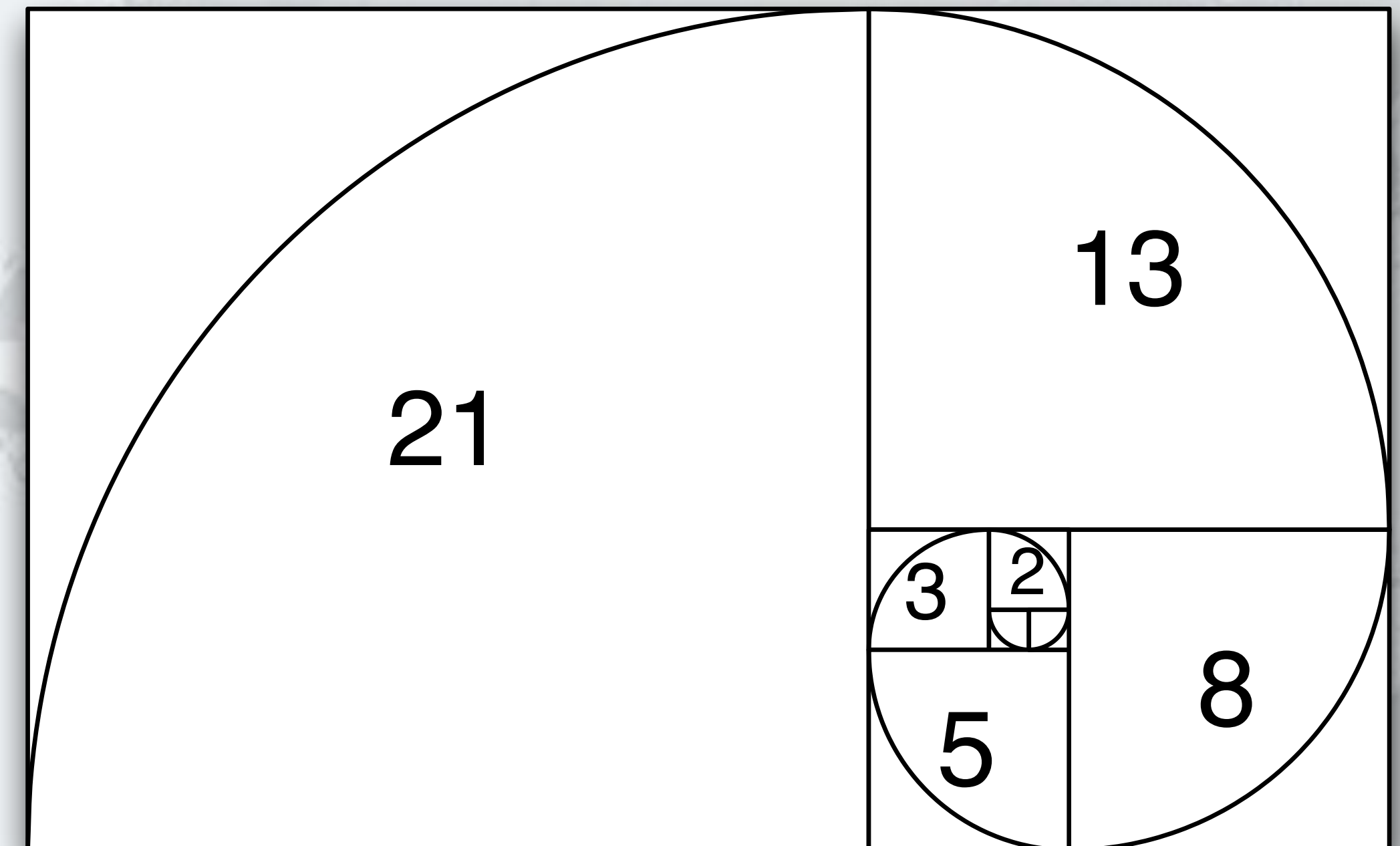
ManagedBlocker

Speeding Up Fibonacci

- **By Leonardo of Pisa**
  - $F_0 = 0$
  - $F_1 = 1$
  - $F_n = F_{n-1} + F_{n-2}$

- **Thus the next number is equal to the sum of the two previous numbers**
  - e.g. 0, 1, 1, 2, 3, 5, 8, 13, 21, …

- **The numbers get large quickly, like Australian rabbit population**
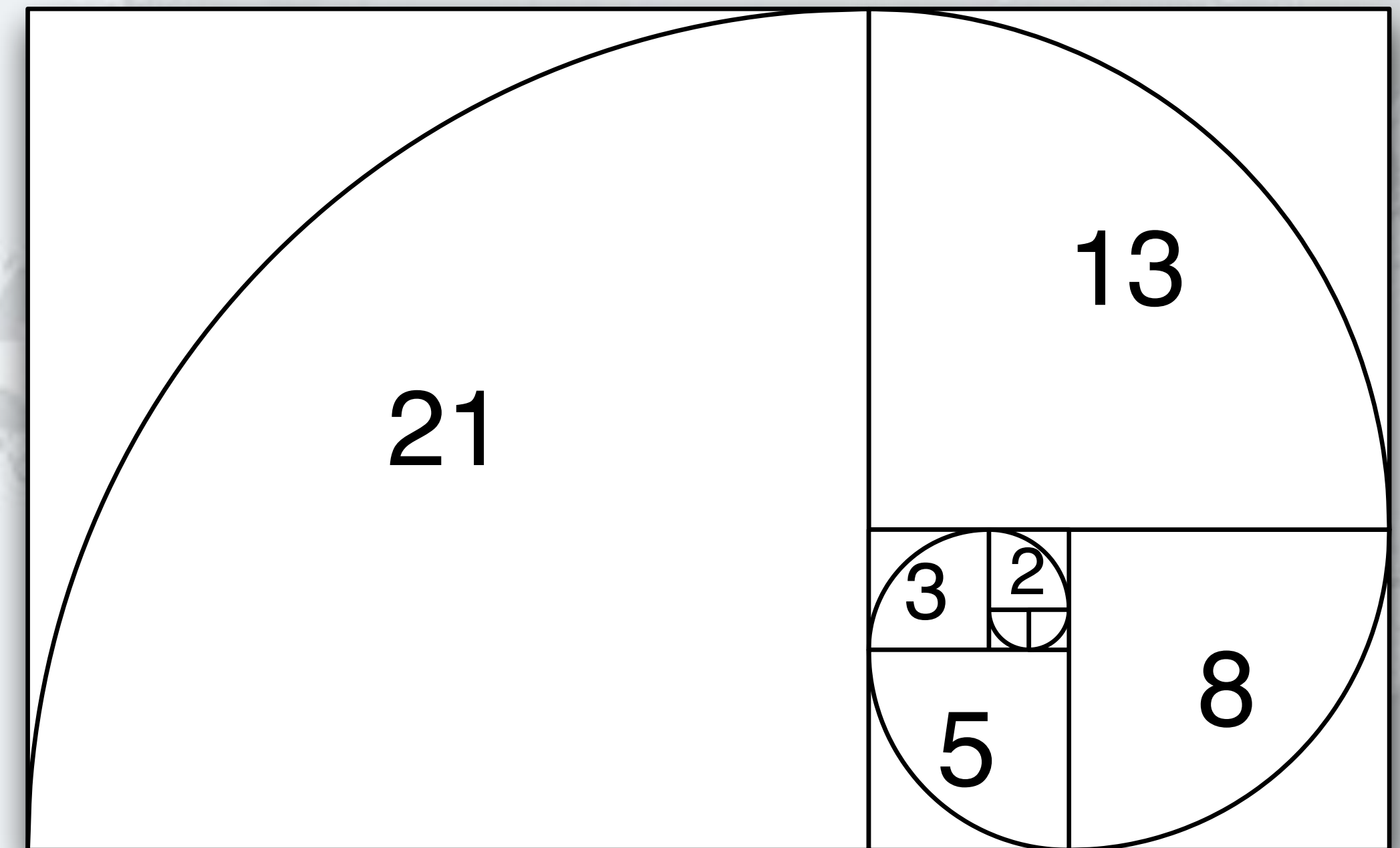
21

13

3 2

5

8

Naive Implementation

- **Taking our recursive definition**

  – $F_0 = 0$, $F_1 = 1$

  – $F_n = F_{n-1} + F_{n-2}$

- **Converting this into Java:**

```java
public long f(int n) {
    if (n <= 1) return n;
    return f(n-1) + f(n-2);
}
```

- **But this has exponential time complexity, so gets terribly slow**

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2nd Attempt at Coding Fibonacci

- **Iterative algorithm**

```java
public static long f(int n) {
  long n0 = 0, n1 = 1;
  for (int i = 0; i < n; i++) {
    long temp = n1;
    n1 = n1 + n0;
    n0 = temp;
  }
  return n0;
}
```


- **Linear time complexity**

  – **f(1_000_000_000) in 1.7 seconds**

    • **However, long overflows so the result is incorrect**

    • **We can use BigInteger, but its add() is also linear, so time is quadratic**

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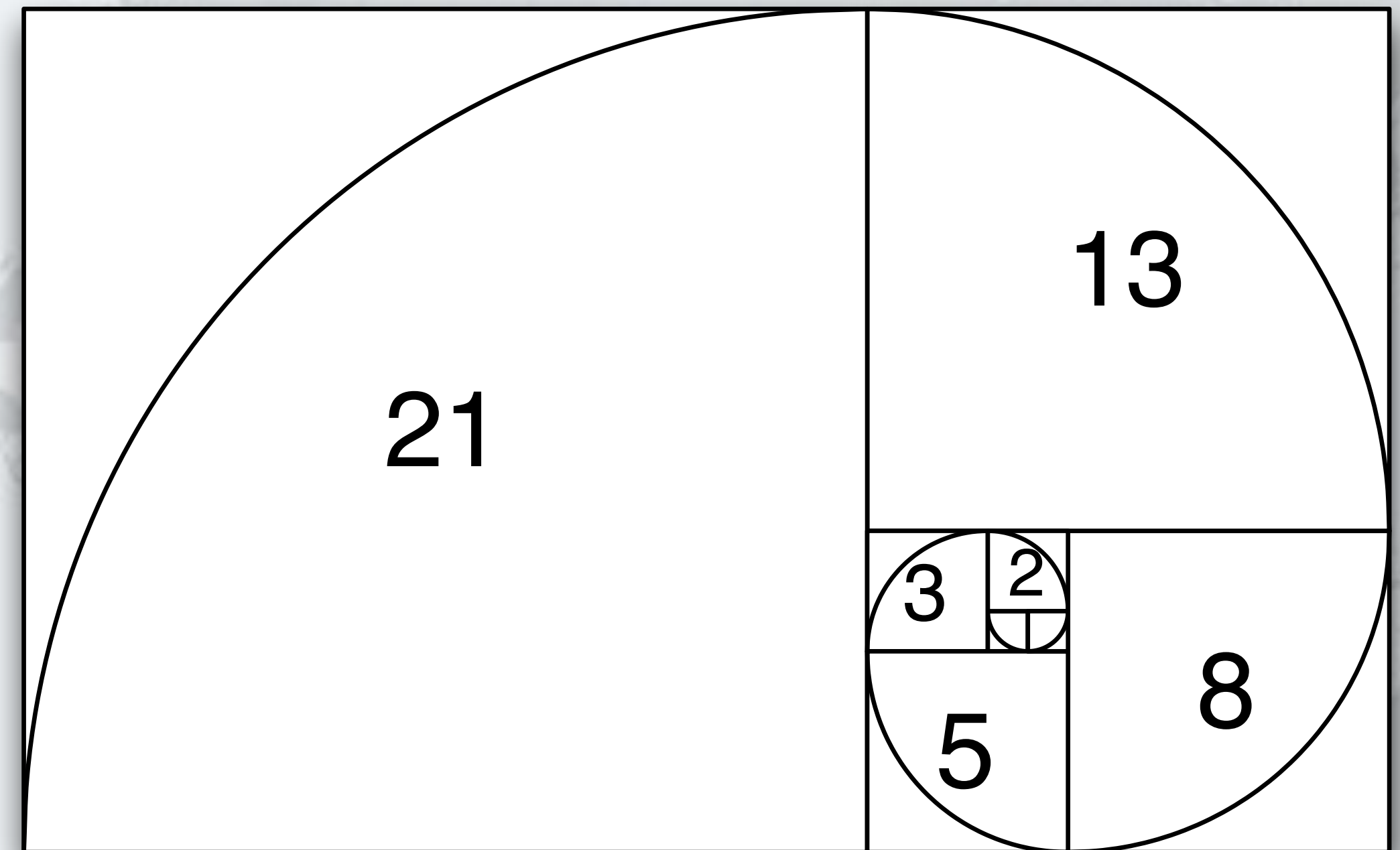
3rd Attempt Dijkstra's Sum of Squares

- **Dijkstra's clever formula**

  - $F_{2n-1} = F_{n-1}^2 + F_n^2$

  - $F_{2n} = (2 \times F_{n-1} + F_n) \times F_n$

- **Logarithmic time complexity**

- **Multiply in Java BigInteger**

  - **Karatsuba complexity is O($n^{1.585}$)**

  - **3-way Toom Cook complexity is O($n^{1.465}$)**

  - **Prior to Java 8, multiply() had complexity O(n^2)**

  - **BigInteger.multiply() single-threaded in Java - we'll fix that later**

21 13 3 2 5 8
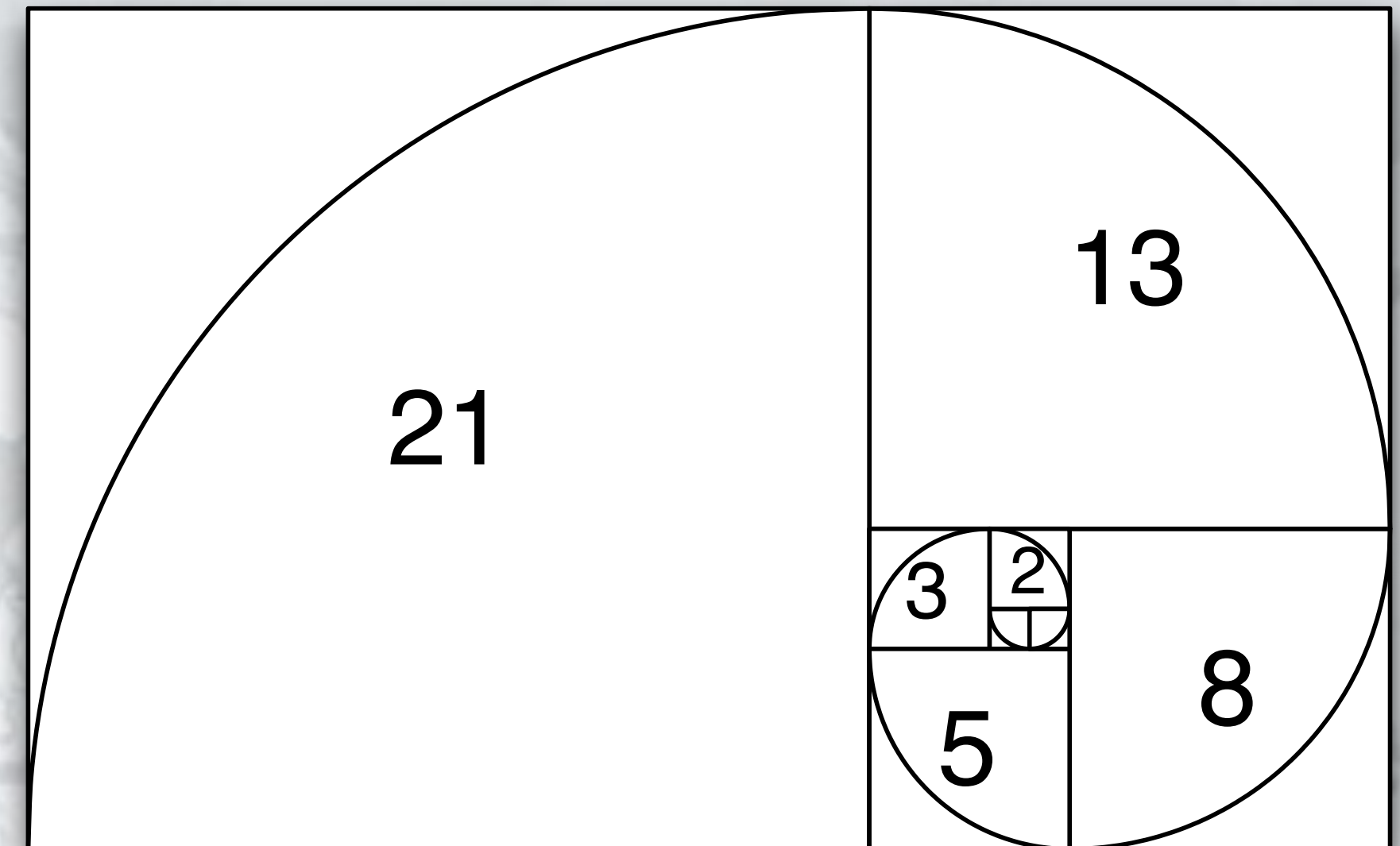
Demo 1: Dijkstra's Sum of Squares

- **We implement this algorithm using BigInteger**

  - $F_{2n-1} = F_{n-1}^2 + F_n^2$

  - $F_{2n} = (2 \times F_{n-1} + F_n) \times F_n$

- **Please remind me to commit each step to github**

  - **tinyurl.com/jprime17**

Demo 2: Parallelize Our Algorithm

- **We can parallelize by using common Fork/Join Pool**

  - **Next we fork() the 1st task, do the 2nd and then join 1st**

```java
RecursiveTask<BigInteger> f0_task = new RecursiveTask<BigInteger>() {
    protected BigInteger compute() {
        return f(half - 1);
    }
};
f0_task.fork();
BigInteger f1 = f(half);
BigInteger f0 = f0_task.join();
```

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Demo 3: Parallelize BigInteger

- **Let's hack fork/join into:**
  - **multiplyToomCook3()**
  - **squareToomCook3()**

- **These probably won't reach the threshold**
  - **multiplyKaratsuba()**
  - **squareKaratsuba()**

- **Choose modified BigInteger with**
  - **-Xbootclasspath/p:<path_to_hack>**

Level 0 1 000 000

Level 1 499 999   500 000

Level 2 249 999   250 000   249 999   250 000

- -

Level 5 16 x 31 249   16 x 31 250

Level 6 32 x 15 624   32 x 15 625

Level 7 32 x 7 811   64 x 7 812   32 x 7 813

- -

Level 14 7 904 x 60   8 192 x 61   288 x 62

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Demo 4: Cache Results

- **Dijkstra's Sum of Squares needs to work out some values several times. Cache results to avoid this.**
  - **Careful to avoid a memory leak**
    - **No static maps**

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Demo 5: Reserved Caching Scheme

● **Instead of calculating same value twice:**

– **Use putIfAbsent() to insert special placeholder**

– **If result is null, we are first and start work**

– **If result is the placeholder, we wait**

Demo 6: ManagedBlocker

- **ForkJoinPool is configured with *desired parallelism***
  - **Number of active threads**
  - **ForkJoinPool mostly used with CPU intensive tasks**

- **If one of the FJ Threads has to block, a new thread can be started to take its place**
  - **This is done with the ManagedBlocker**

- **We use ManagedBlocker to keep parallelism high**

Demo 7: CompletableFuture (Homework)

- **Implement Fibonacci using**

  - **CompletableFuture with methods**

    - **thenAcceptBothAsync()**

    - **complete()**

  - **What happens with thread creation when you disable the common ForkJoinPool?**

    - **-Djava.util.concurrent.ForkJoinPool.common.parallelism=0**

- **Send me your answers here: tinyurl.com/jprime17**

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