

Turbo Charge CPU Utilization in Fork/Join Using the ManagedBlocker

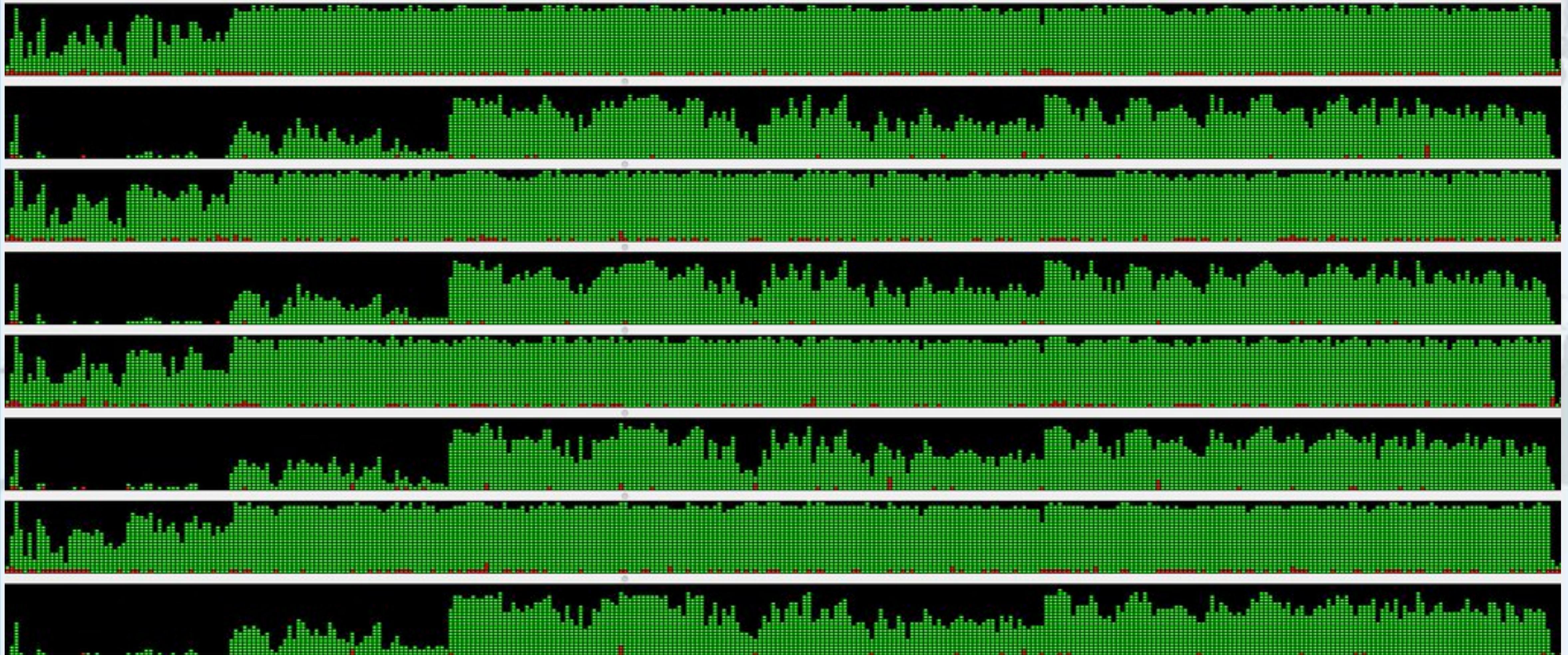
Dr Heinz M. Kabutz

Last Updated 2018-06-01

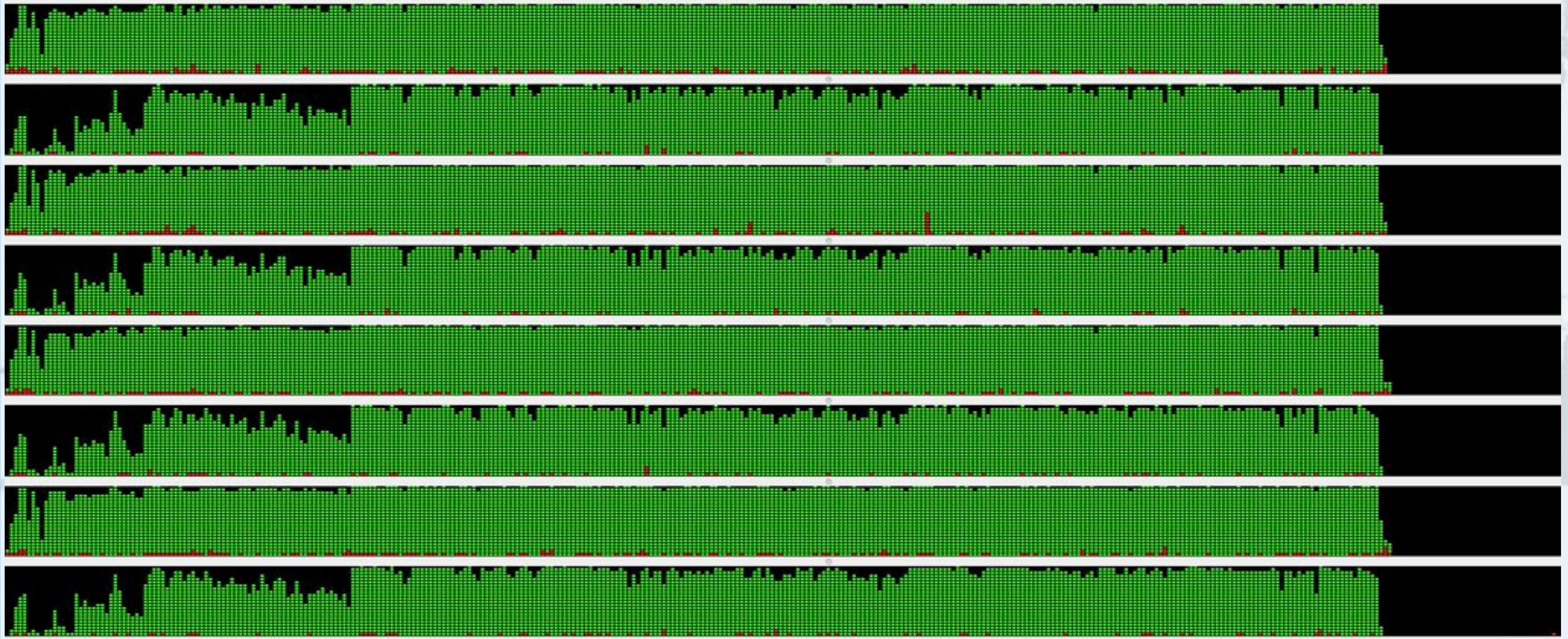


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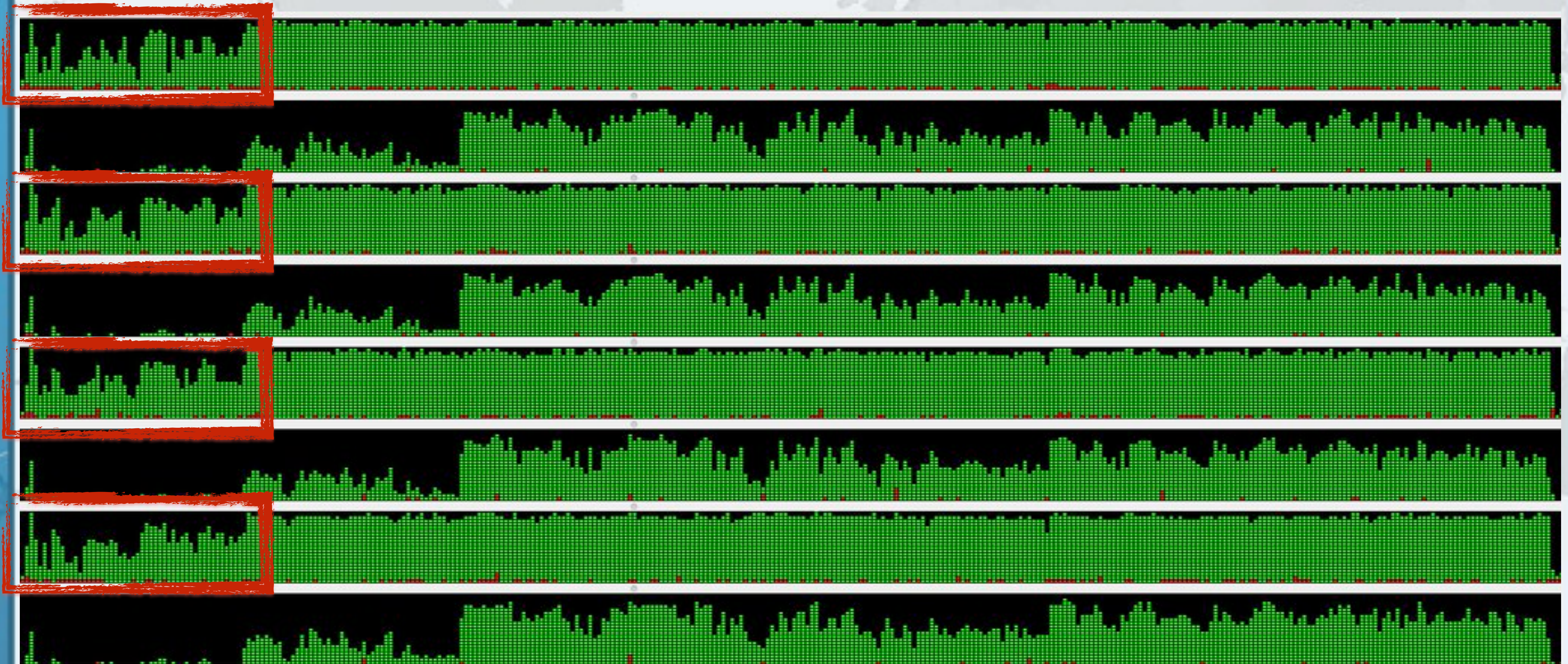
Regular Fibonacci 1.000.000.000



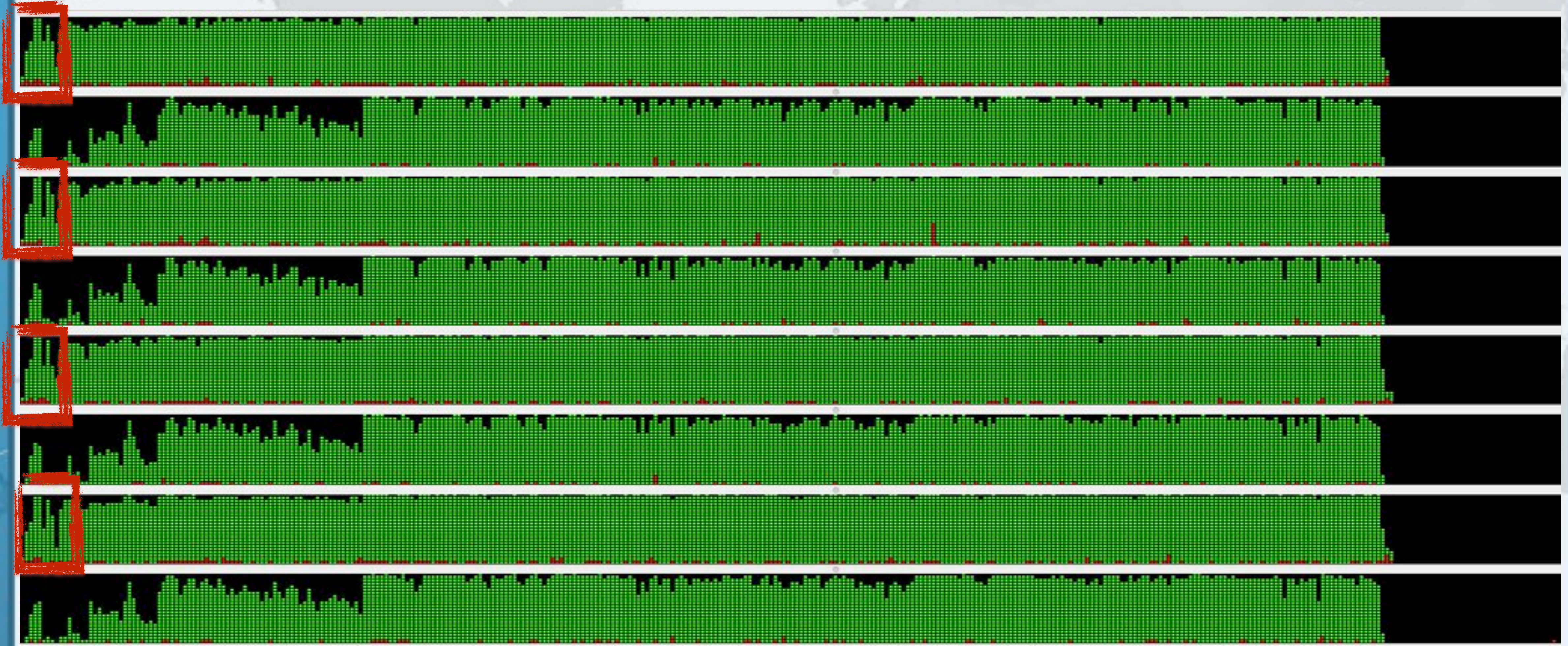
ManagedBlocker Fibonacci 1.000.000.000



Initial Startup Regular Fib 1 billion



Better Utilization In the Beginning



Speeding Up Fibonacci

- **By Leonardo of Pisa**

- $F_0 = 0$

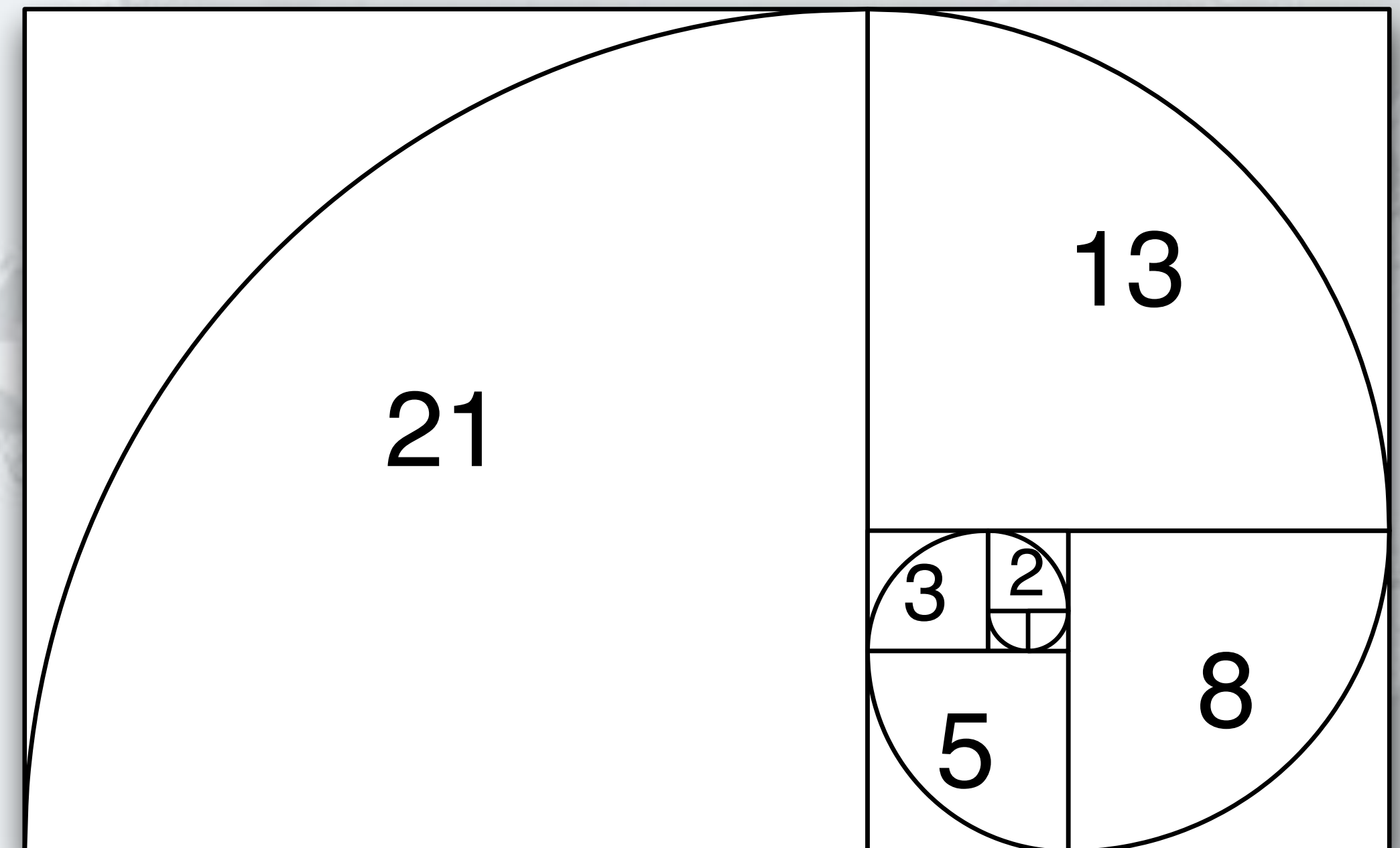
- $F_1 = 1$

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

- **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



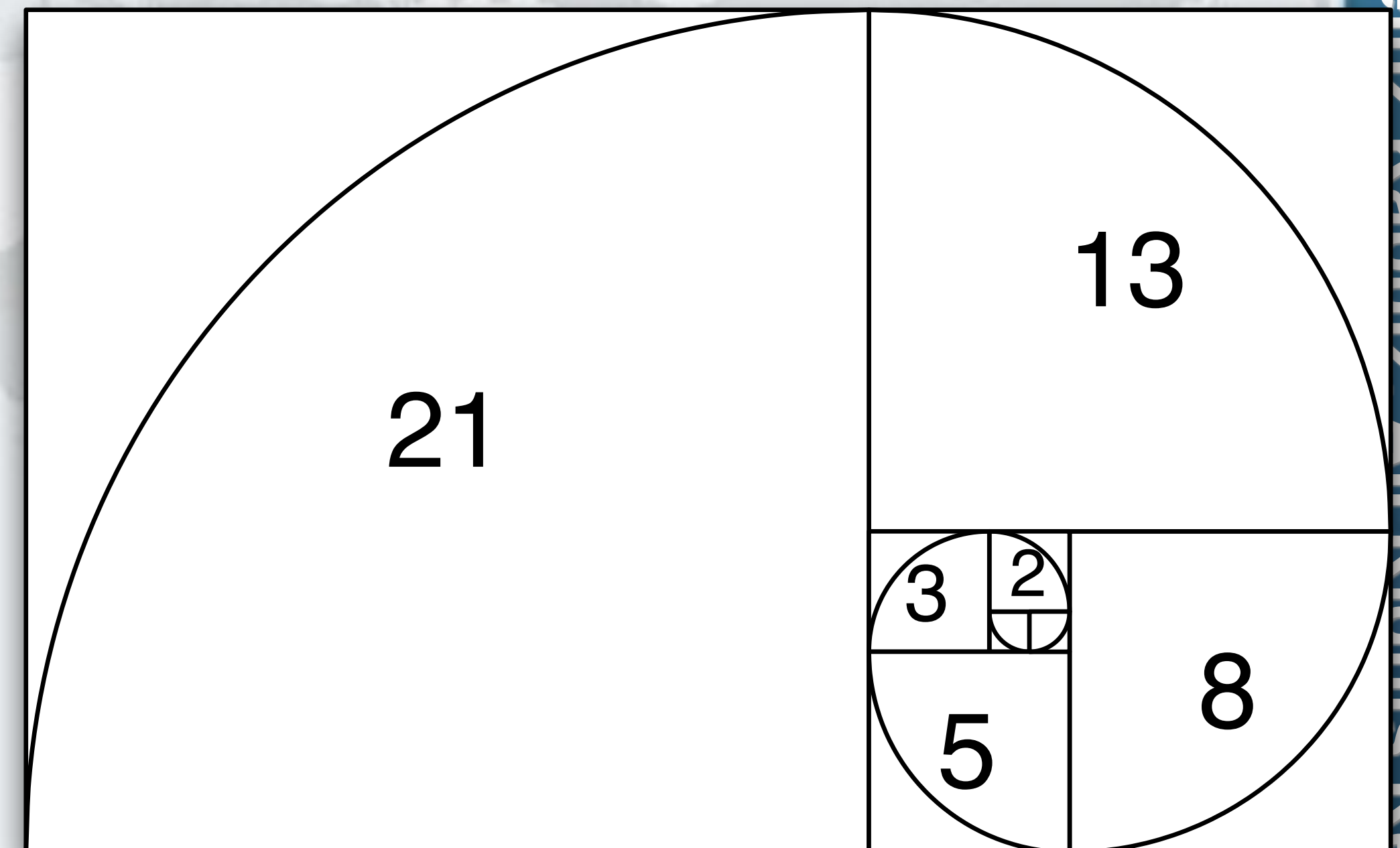
Naive Implementation

- Taking our recursive definition

- $F_0 = 0, F_1 = 1$
- $F_n = F_{n-1} + F_{n-2}$

- Converting this into 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

2nd Attempt at Coding Fibonacci

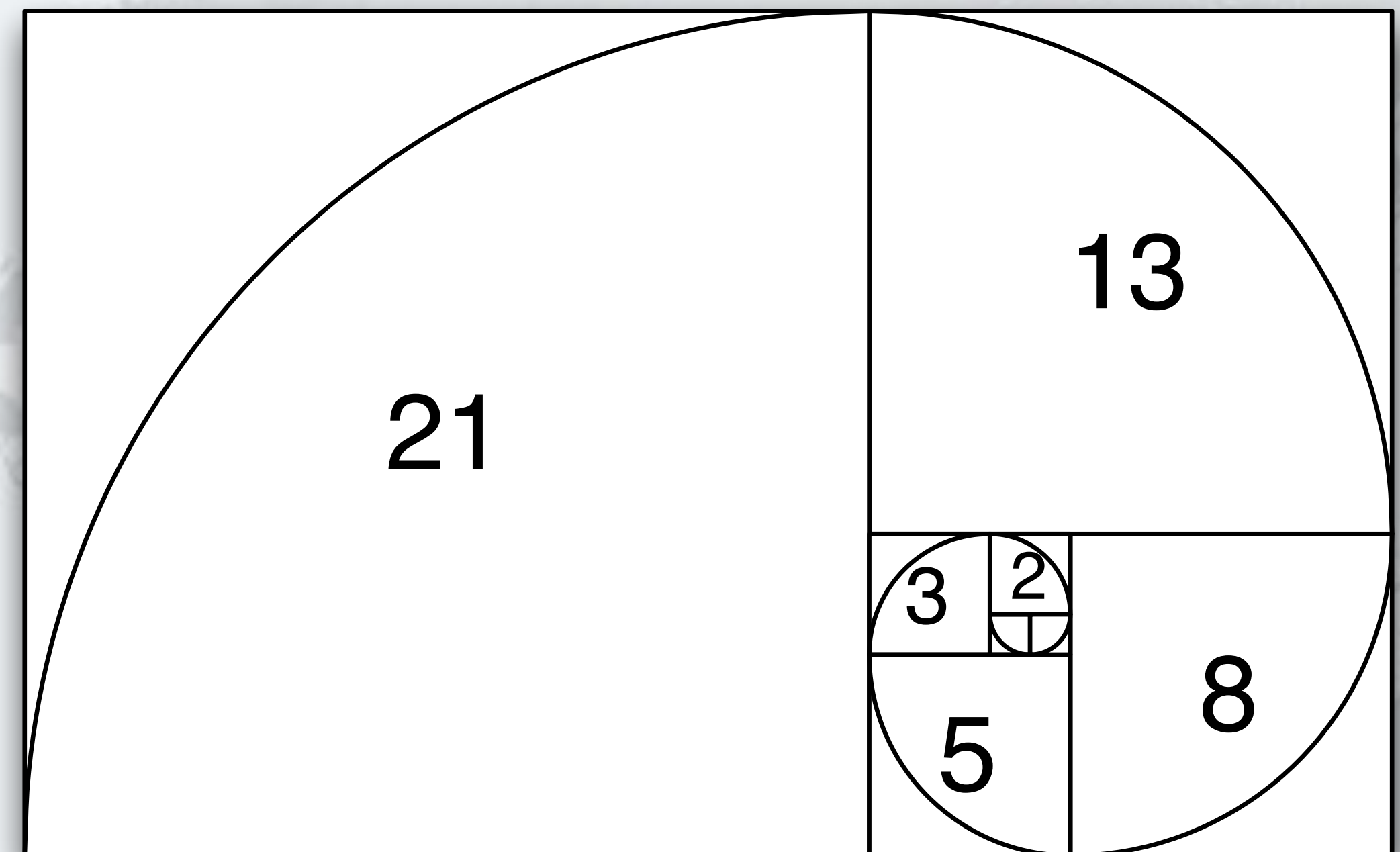
- **Iterative algorithm**

```
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 400 ms**

- However, long overflows when n=93, so only lower 64 bit are correct
- We can use BigInteger, but its add() is also linear, so time is quadratic



3rd Attempt Dijkstra's Sum of Squares

- **Dijkstra's clever formula**

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

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

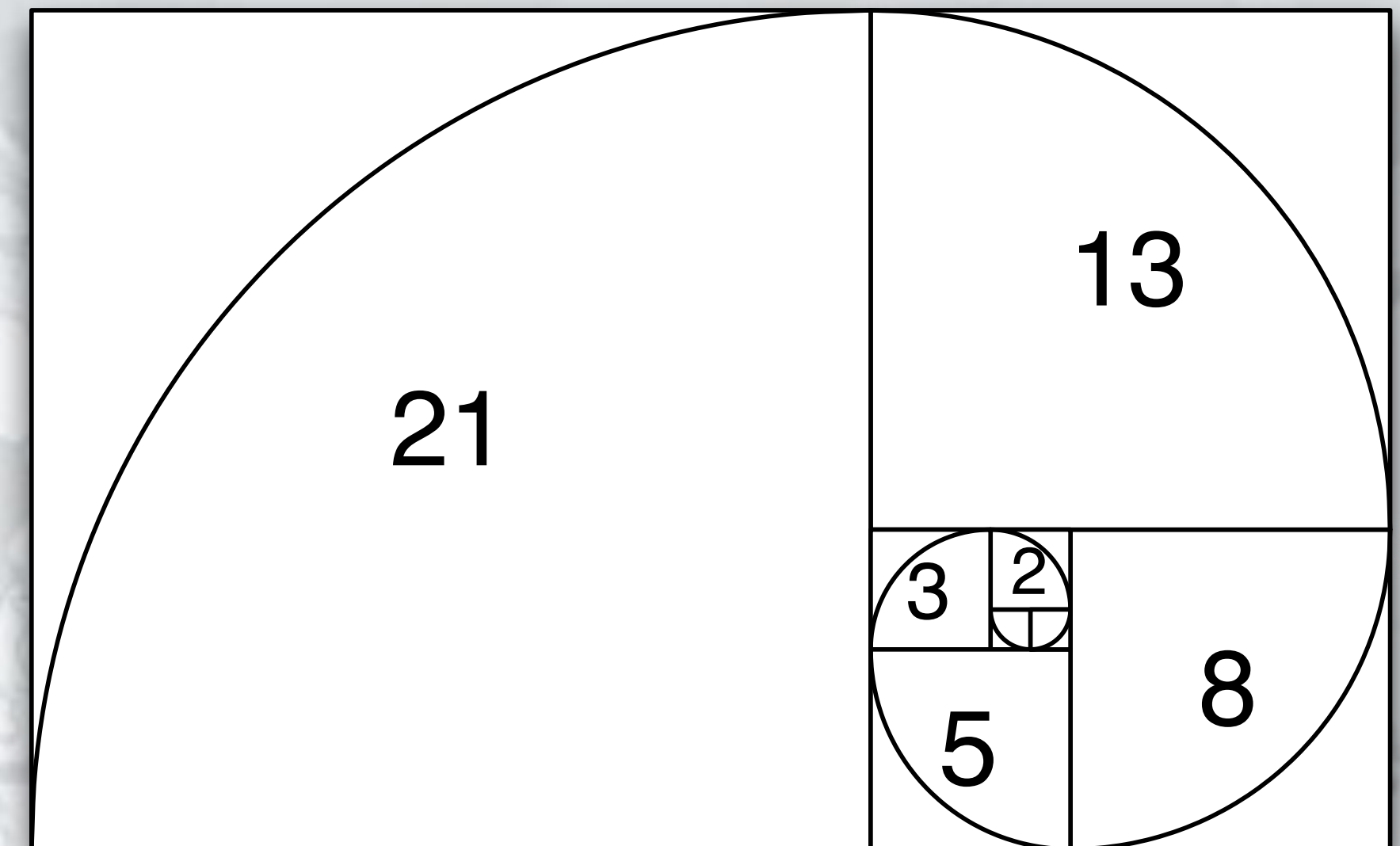
- **Logarithmic time complexity**

- Multiply in BigInteger used to be $O(n^2)$

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

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

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



Demo 1: Dijkstra's Sum of Squares

- **Let's implement this algorithm using BigInteger**
 - $F_{2n-1} = F_{n-1}^2 + F_n^2$
 - $F_{2n} = (2 \times F_{n-1} + F_n) \times F_n$

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

```
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();
```

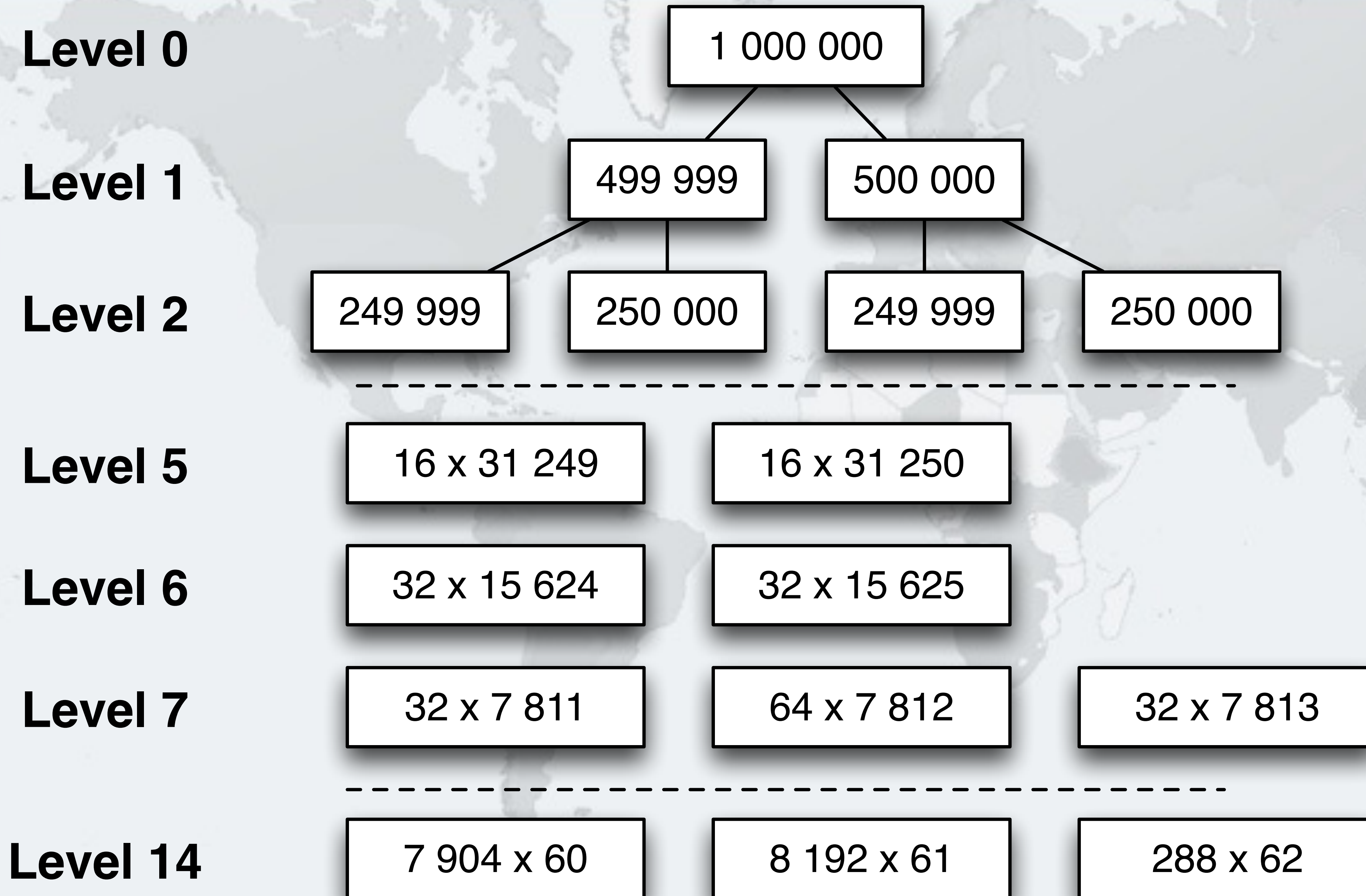

Demo 3: Parallelize BigInteger

- **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>`
 - Java 9+ a bit more complicated - create a patch for module

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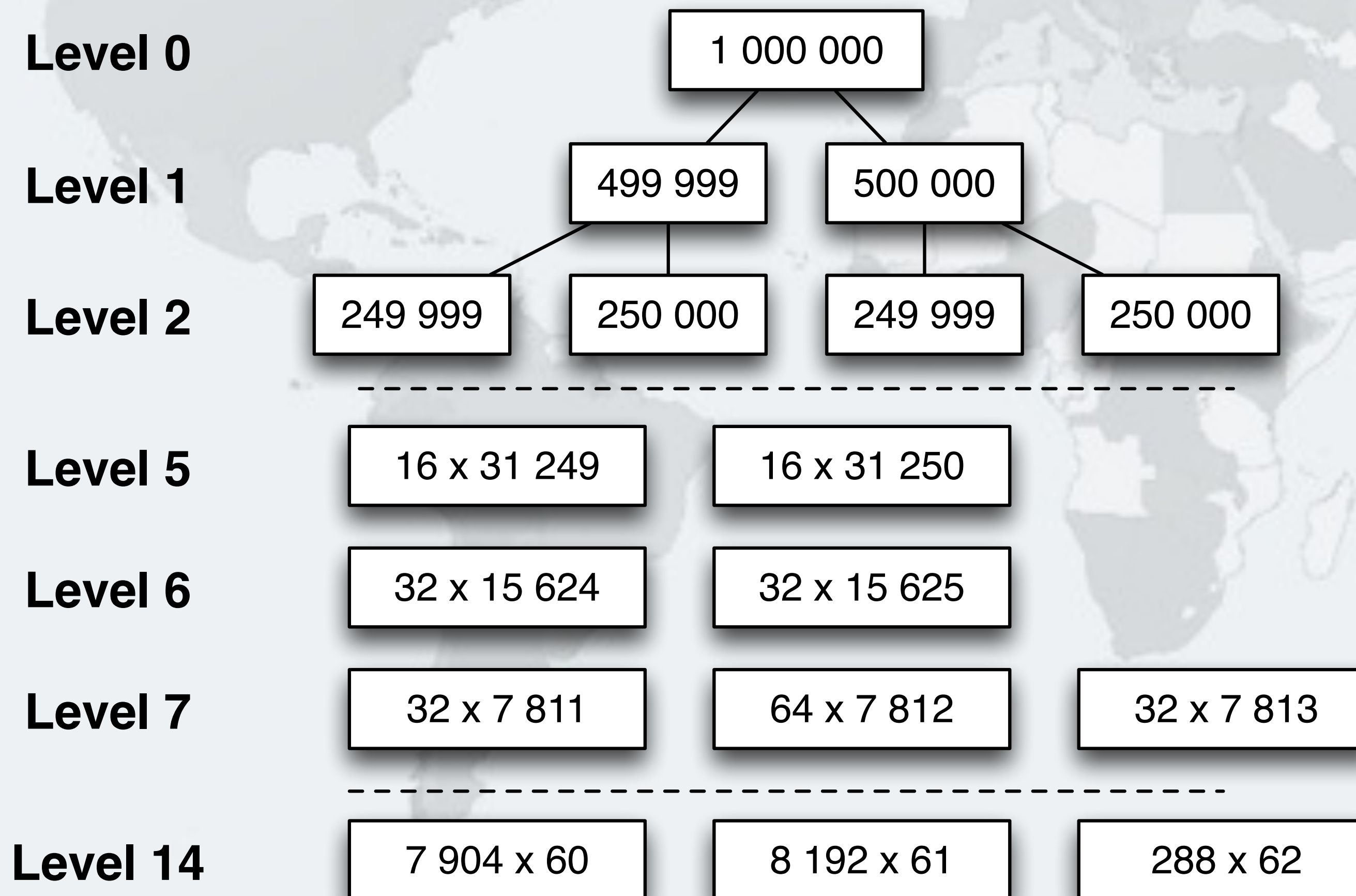




Demo 4: Cache Results

- **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**

Similar Concurrent Requests Likely



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()**
 - **How many threads are created when we disable the common pool?**
 - **-Djava.util.concurrent.ForkJoinPool.common.parallelism=0**
- **Send your answers to heinz@javaspecialists.eu**

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