UNIVERSITY OF SAN FRANCISCO
CHANGE THE WORLD FROM HERE

Concurrency

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Concurrency

- What is concurrency?

Concurrency

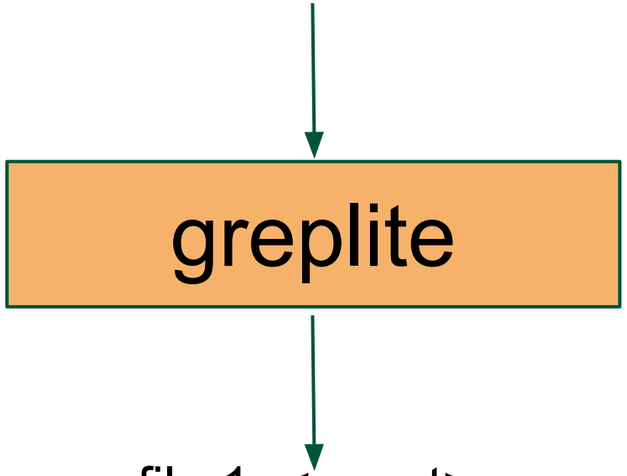
- **What is concurrency?**
  - Executing multiple tasks simultaneously
    - Processing multiple HTTP requests at the same time

- **Why concurrency?**
  - Improve performance
    - Take advantage of multiple cores
    - Do useful computation when blocked on i/o
  - Allow background activities

GrepLite

searchterm: computing

directory: /Users/srollins/GrepTool/myfiles



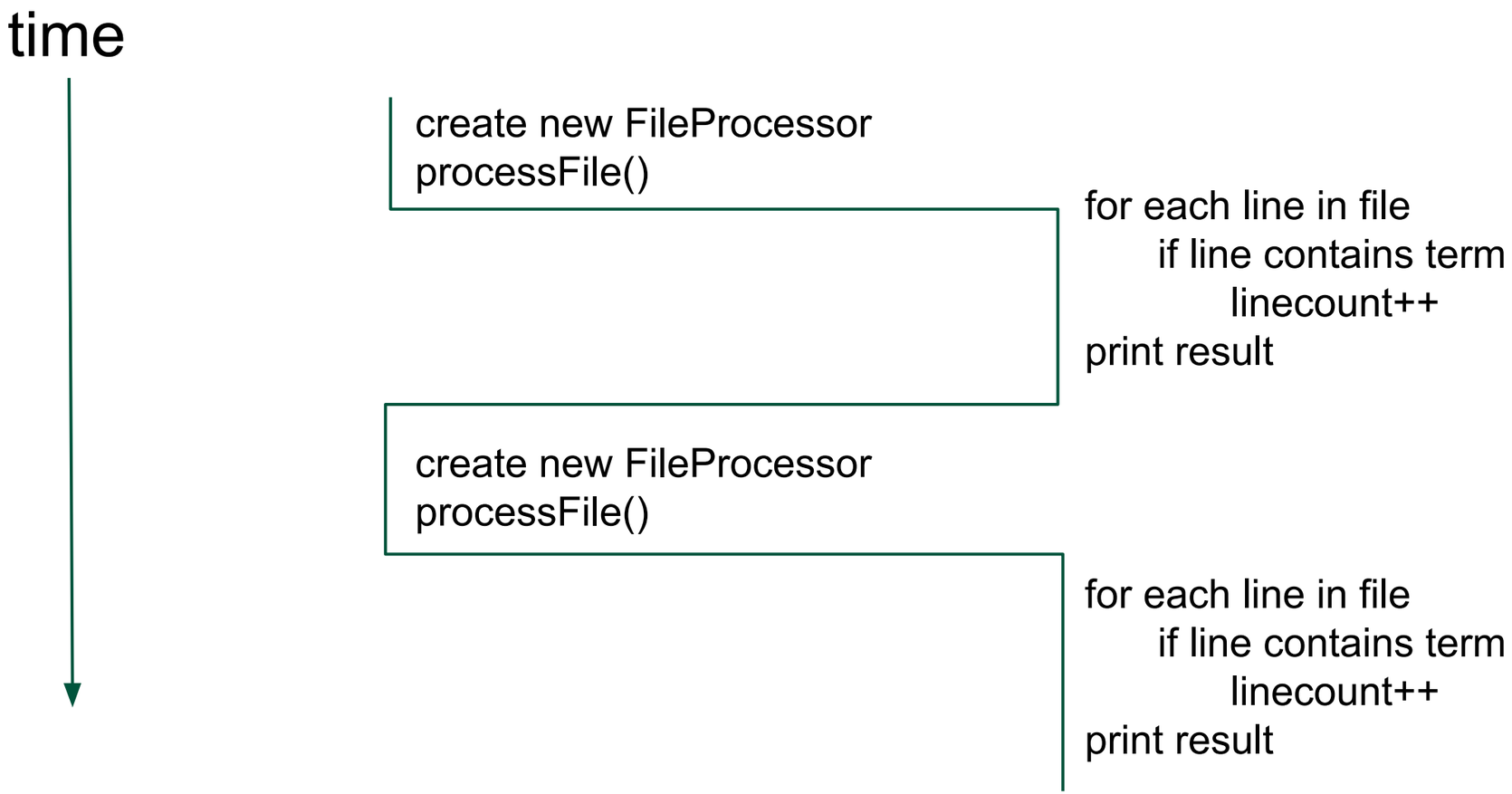
file 1: <count>

file 2: <count>

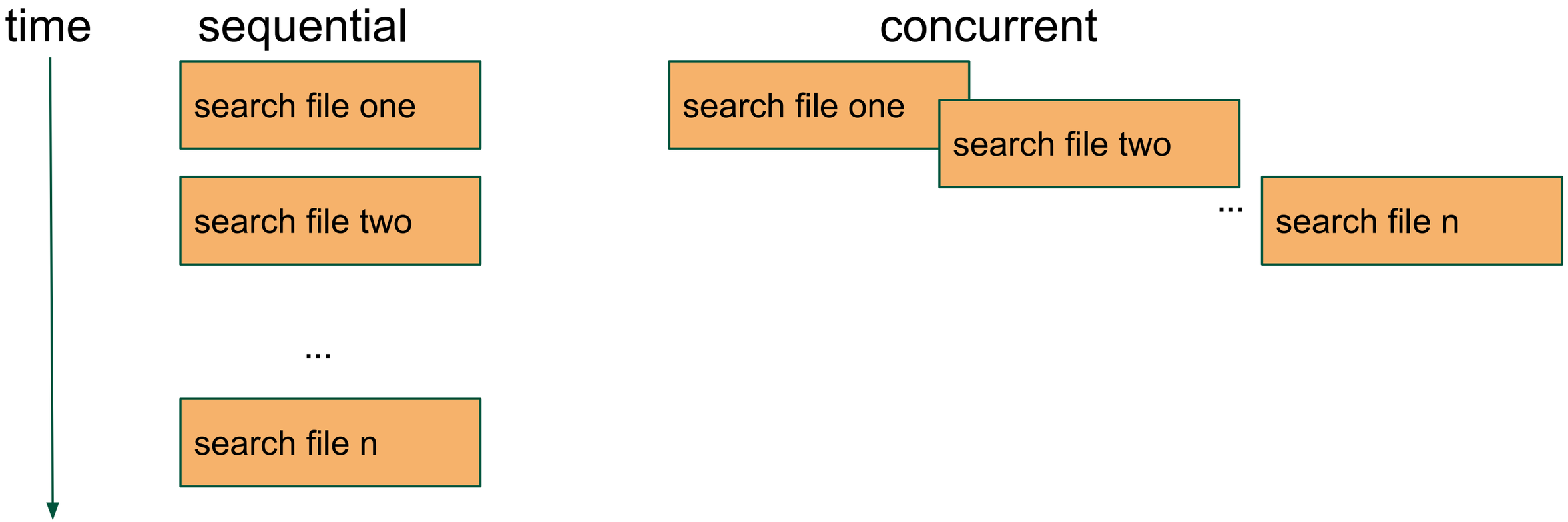
…

file n: <count>

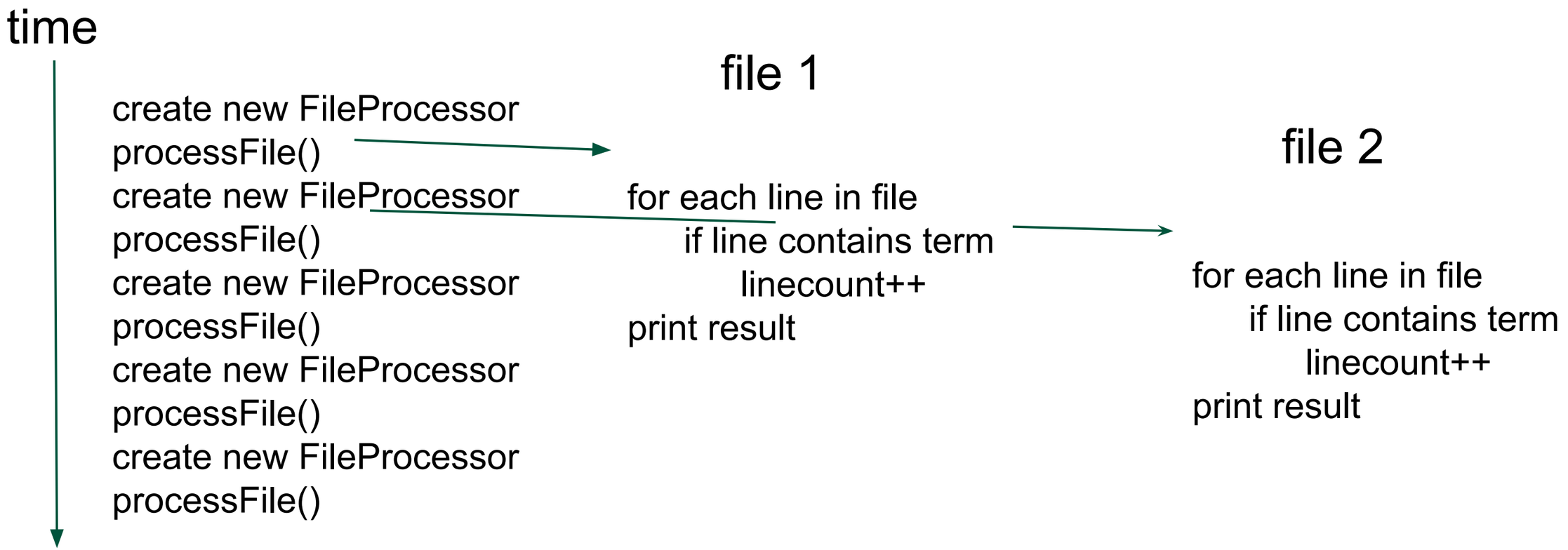
GrepLite Algorithm - Sequential



Sequential versus Concurrent

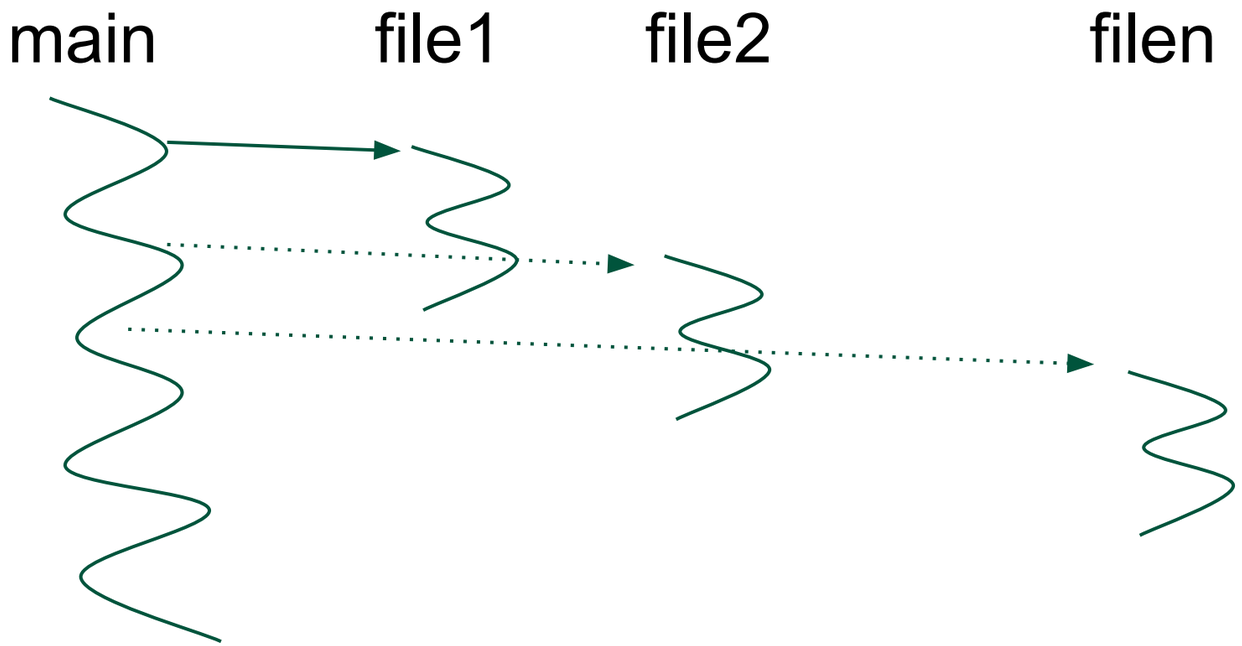


GrepLite Algorithm - Concurrent



Threads

- **Programming abstraction that allow *lightweight processes* within an application**



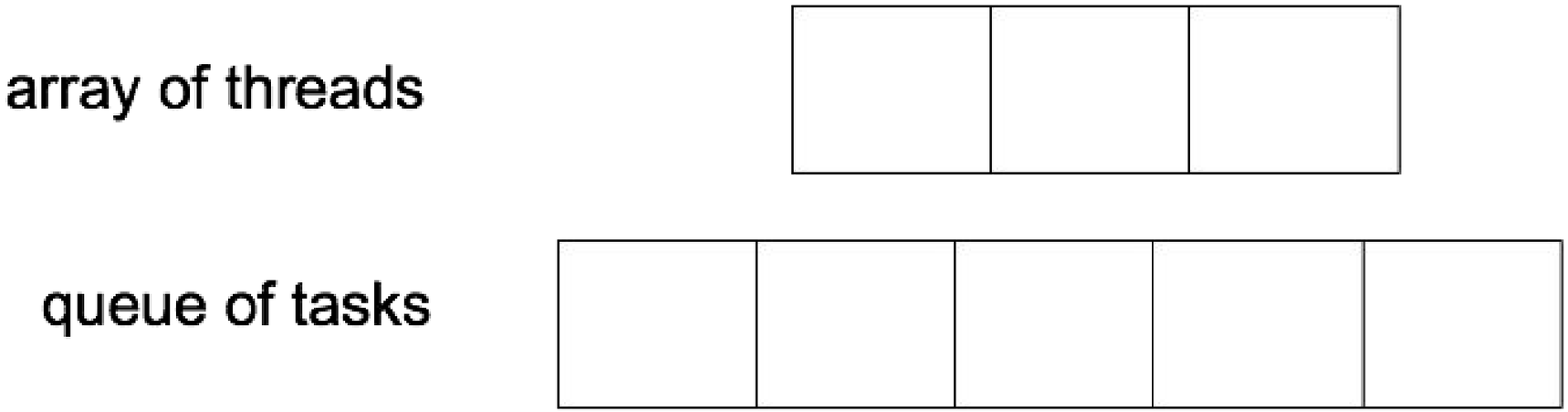
Challenges

- **Order of execution**
  - Race conditions
- **Inter-thread communication**
- **Shared data and thread safety**
- **Overhead**

Thread pool

- There is an overhead associated with creating and destroying threads
  - Each operation requires a new thread

- A solution is to create a *pool* of a fixed number of threads. As tasks arrive, a thread from the pool is used to execute the task.



Communication

- Threads *wait* for new work

- When new work is inserted, the queue must *notify* the threads that new work is available
- `wait` and `notify` are Java keywords.
- `wait` can be called on any object. The thread that calls `wait` suspends execution until it is *woken up* with a `notify` message called on the same object.
- In most cases, `notifyAll` is used instead of `notify`. `notifyAll` will wake up every thread that has called `wait` on the given object.

Threads and sharing

- Atomic operations
  - Suppose two threads operate on the same data
  - a initially has the value of 4

Thread 1:
```
a = a + 1;
```

Thread 2:
```
a = a * 2;
```

- What are the possible resulting values for a?
  - 10 (4 + 1 = 5, 5 * 2 = 10)
  - 9 (4 * 2 = 8, 8 + 1 = 9)
  - how about 5 or 8?

Threads and sharing

- a = a + 1
  - 1. read value of a
  - 2. set a to a + 1
- a = a * 2
  - 3. read value of a
  - 4. set a to a * 2

Option 1: 1, 2, 3, 4 -- a will be10
Option 2: 3, 4, 1, 2 -- a will be 9
Option 3: 1, 3, 2, 4 -- a will be 8
Option 4: 1, 3, 4, 2 -- a will be 5
BUT, options 3 and 4 should never occur

Atomic operations

- *atomic* operations execute without interference from other operations
- request a *lock* before an operation, release it when the operation is complete
- `synchronized` is a Java keyword that acquires a lock on an object
  - `synchronized` may be used for methods or blocks of statements
- synchronized methods may not interleave