Ordered Printing

This problem is about imposing an order on thread execution.

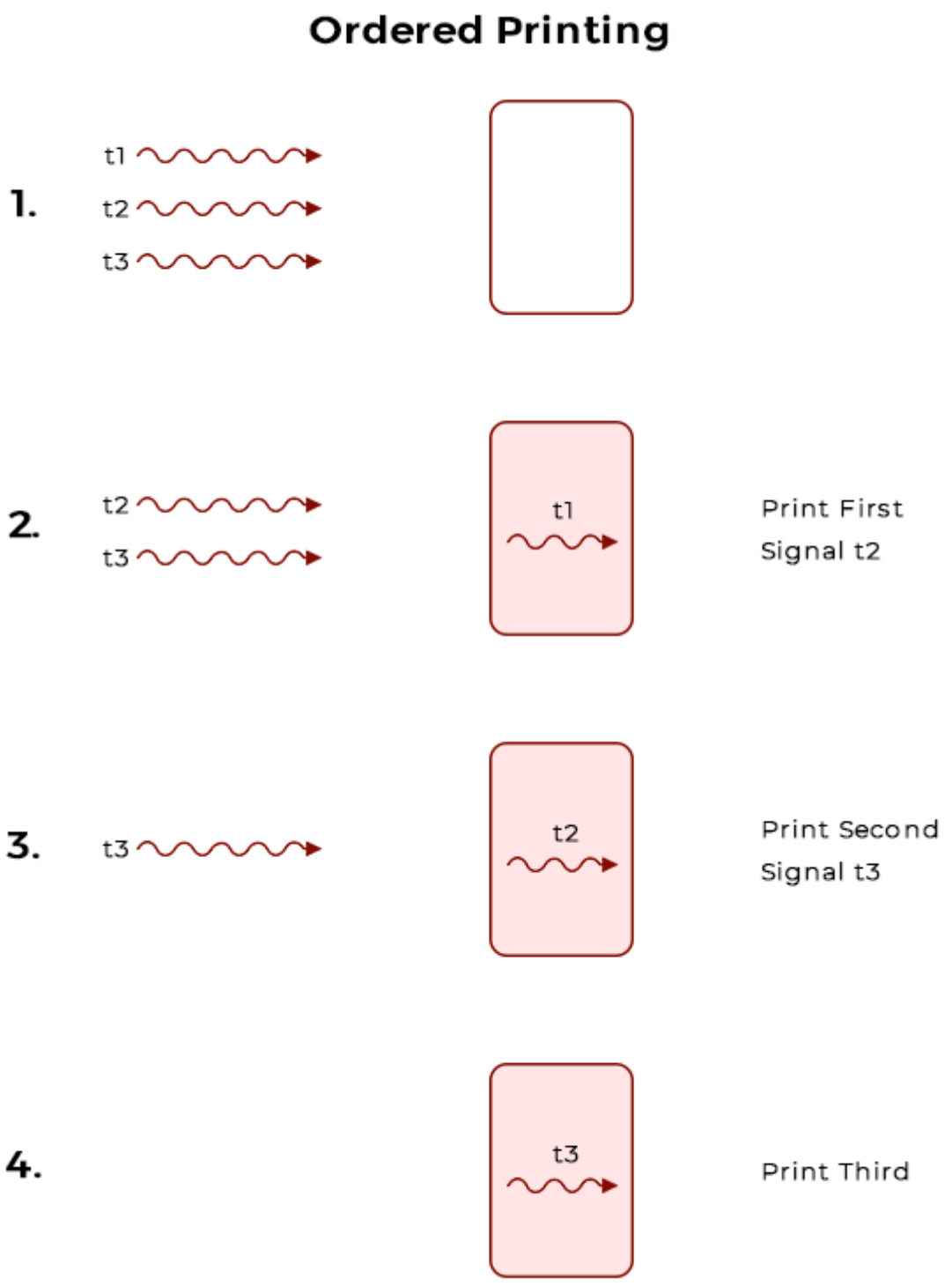
Problem

Suppose there are three threads t1, t2 and t3. t1 prints **First**, t2 prints **Second** and t3 prints **Third**. The code for the class is as follows:

```
class OrderedPrinting

    def printFirst()
       puts "First"
    end

    def printSecond()
       puts "Second"
    end

    def printThird()
       puts "Third"

end
```

Thread t1 calls printFirst(), thread t2 calls printSecond(), and thread t3 calls printThird(). The threads can run in any order. You have to synchronize the threads so that the functions **printFirst()**, **printSecond()** and **printThird()** are executed in order.

The workflow of the program is shown below:



Workflow

Solution

The class `OrderedPrinting` consists of one class variable `job` and two synchronization primitives offered by Ruby; `mutex` & condition variable (`cv`). Mutex is used to coordinate access to shared data from various

parallel threads. Anything written within the `synchronize{}` block is locked until it completes execution.

Class variables can be defined as global variables within the context of a single class. They are shared among all instances of a class and are declared with the @@ sign. Global variable `job` is initialized with 0 so that "First" is always printed first. The basic structure of the class is displayed below:

```
class OrderedPrinting

    def initialize
        @mutex = Mutex.new
        @cv = ConditionVariable.new
        @@job = 0
    end

    def printFirst
    end

    def printSecond
    end

    def printThird
    end

end
```

The first method `printFirst()` starts with a `mutex`.synchronize block that locks the access to shared resources. It prints "First" and then increments the global variable `job` indicating Second's turn to be printed. Before releasing the `mutex`, `cv` broadcasts to all the waiting threads that the current thread is finished working and `mutex` is free to be acquired.

```
def printFirst
    #synchronize ensures only 1 method manipulates job.
    @mutex.synchronize do
        puts "First"
        @@job+=1
        @cv.broadcast
    end
```

```
end
```

The second method `printSecond()` works in the same manner as `printFirst()` with an addition of a while loop that checks if `job` is equal to 1. If it is, then the loop breaks and "second" is printed, otherwise the thread waits on the condition variable `cv`. After "second" is printed, `job` is incremented and `cv` notifies all the waiting threads.

```
def printSecond
    @mutex.synchronize do
        #if value of job is not 1 then wait
        while (@@job != 1)
            @cv.wait(@mutex)
        end
        #if job is 1 then print, increment, broadcast and exit the lo
op.
        puts "Second"
        @@job+=1
        @cv.broadcast
    end
end
```

The while loop in `printThird()` checks if `job` is equal to 2. If it is, then "Third" is printed otherwise it goes into wait.

```
def printThird
    @mutex.synchronize do
        #if value of job is not 2 then wait
        while (@@job != 2)
            @cv.wait(@mutex)
        end
        #if job is 2 then print, brpadcast and exit the loop.
        puts "Third"
        @cv.broadcast
    end
end
```

To test our solution, we will create three threads and each thread will be passed the same object of `OrderedPrinting`. **t1** will call `printFirst()`, **t2** will call `printSecond()` and **t3** will call `printThird()`. The output shows

printing done in proper order irrespective of the calling order of threads.

```
class OrderedPrinting

        def initialize
            @mutex = Mutex.new
                @cv = ConditionVariable.new
                @@job = 0
        end

        def printFirst
                #synchronize makes sure only one method manipulates job at a given time.
                @mutex.synchronize do
                puts "First"
                        @@job+=1
                        @cv.broadcast
                end
        end

        def printSecond
                @mutex.synchronize do
                        #if job is not 1 then wait
                        while (@@job != 1)
                                @cv.wait(@mutex)
                        end
                #if job is 1 then print, increment, broadcast and exit the loop.
                puts "Second"
                        @@job+=1
                        @cv.broadcast
                end
        end

        def printThird
                @mutex.synchronize do
                    #if job is not 2 then wait
                        while (@@job != 2)
                                @cv.wait(@mutex)
                        end
                    #if job is 2 then print, broadcast and exit the loop.
                puts "Third"
                        @cv.broadcast
                end
        end

end


class Main

    op = OrderedPrinting.new()

    #creating three threads that execute in random order
    t1 = Thread.new(op) do
                op.printFirst
    end
    t2 = Thread.new(op) do
                op.printSecond
    end
```

```
    t3 = Thread.new(op) do
                op.printThird
    end


    threads = []

    threads << t3
    threads << t1
    threads << t2

    threads.each(&:join)
end
```