Threads

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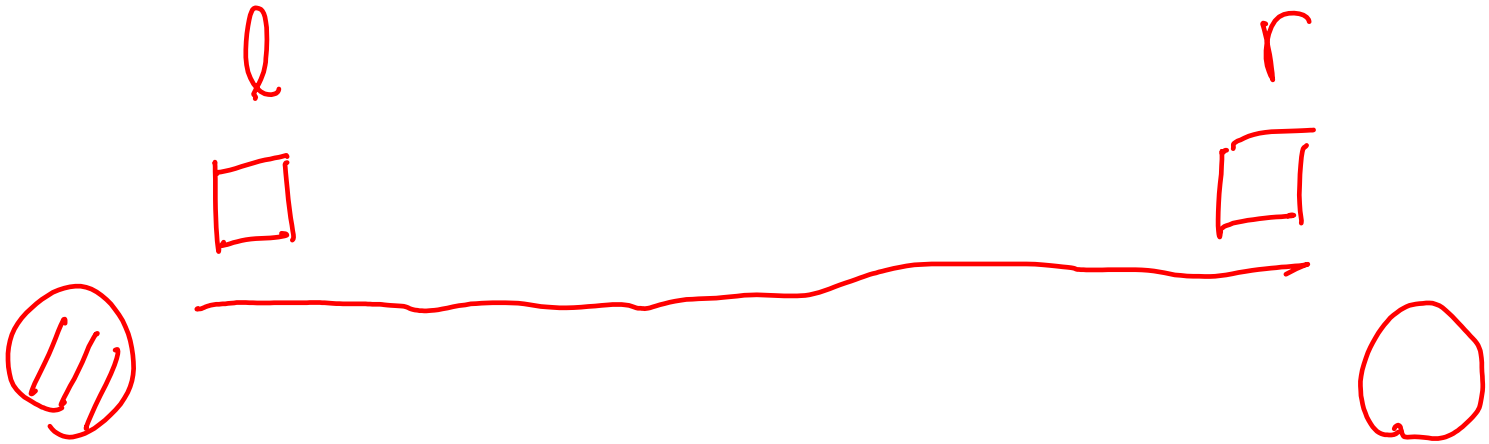
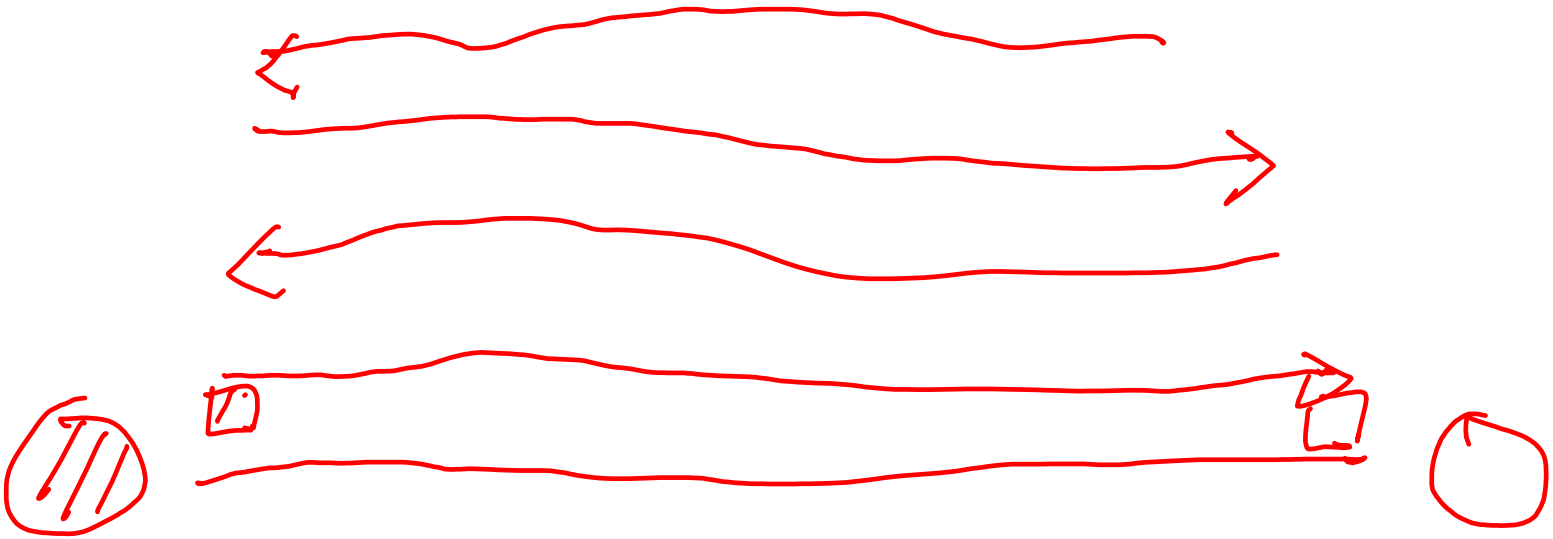
A Story of the Black and White Goats: Deadlock



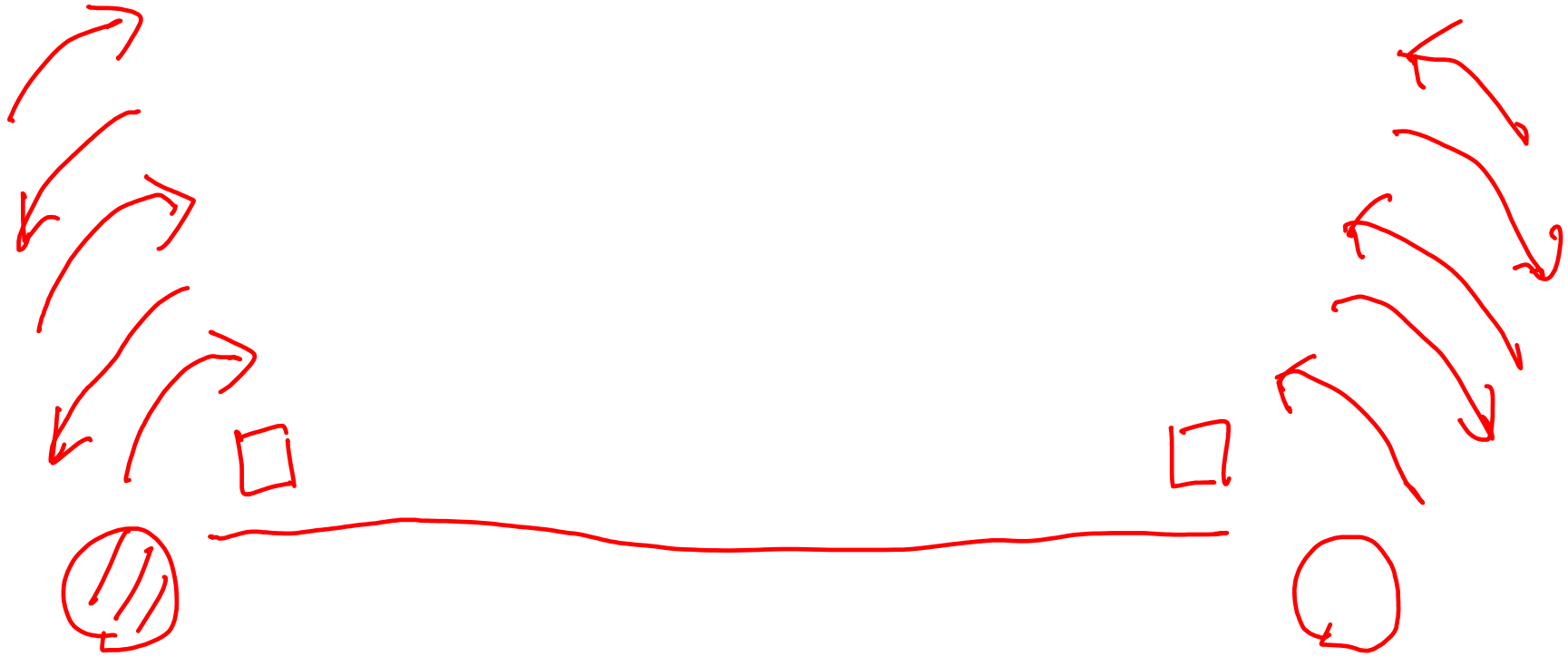

```
synchronized(l){
  synchronized(r){
    gogogo();
  }
}
```

```
synchronized(r){
  synchronized(l){
    gogogo();
  }
}
```

A Story of the Black and White Goats: Starvation



A Story of the Black and White Goats: Livelock



Ways to be Polite

```
1  synchronized void make_payment(int amount){
2    while(no_money()){
3      this.complain(1000);
4    }
5  }
```

```
1  synchronized void make_payment(int amount){
2    while(no_money()){
3      Thread.sleep(1000);
4    }
5  }
6  // ...
```

```
1  synchronized void make_payment(int amount){
2    while(no_money()){
3      this.wait(1000);
4    }
5  }
6  // ...
```

Wait until Notified

```
1   synchronized void make_payment(int amount){
2     while(no_money()){
3       this.wait();
4     }
5   }
6
7   synchronized void get_money(int amount){
8     money += amount;
9     notifyAll();
10  }
```

- difference between `wait` and `sleep`: the former releases the lock temporarily

Producer/Consumer Threads I

```
1  //from Java Tutorial
2  public class Drop {
3      //message sent from producer to consumer
4      private String message;
5      //true if consumer should wait for producer to send msg;
6      //false if producer should wait for consumer to retrieve msg
7      private boolean empty = true;
8
9      public synchronized String take() {
10         //wait until message is available
11         while (empty) {
12             try {
13                 wait();
14             } catch (InterruptedException e) {}
15         }
16         //toggle status
17         empty = true;
18         //notify producer that status has changed
19         notifyAll();
20         return message;
21     }
```

Producer/Consumer Threads II

```
22
23      public synchronized void put(String message) {
24          //wait until message has been retrieved
25          while (!empty) {
26              try {
27                  wait();
28              } catch (InterruptedException e) {}
29          }
30          //toggle status
31          empty = false;
32          //store message
33          this.message = message;
34          //notify consumer that status has changed
35          notifyAll();
36      }
37  }
```

Producer/Consumer Threads III

```
1  //from Java Tutorial
2
3  import java.util.Random;
4
5  public class Producer implements Runnable {
6      private Drop drop;
7
8      public Producer(Drop drop) {
9          this.drop = drop;
10     }
11
12     public void run() {
13         String importantInfo[] = {
14             "I love OOP",
15             "I love Java",
16             "I love PTT",
17             "I love POOCasino",
18         };
19
20
21
```

Producer/Consumer Threads IV

```
22          Random random = new Random();
23
24          for (int i = 0; i < importantInfo.length * 3; i++) {
25              synchronized(drop){
26                  drop.put(importantInfo[i % importantInfo.length]);
27                  System.out.printf("MESSAGE SENT: %s%n",
28                    importantInfo[i % importantInfo.length]);
29              }
30              try {
31                  Thread.sleep(random.nextInt(5000));
32              } catch (InterruptedException e) {}
33          }
34          drop.put("DONE");
35          System.out.println("Producer Exits");
36      }
37  }
```

Producer/Consumer Threads V

```
1  //from Java Tutorial
2  import java.util.Random;
3  public class Consumer implements Runnable {
4      private Drop drop;
5
6      public Consumer(Drop drop) { this.drop = drop; }
7
8      public void run() {
9          Random random = new Random();
10         for (String message = drop.take();
11              !message.equals("DONE");
12              message = drop.take()) {
13             System.out.format("MESSAGE␣RECEIVED:␣%s%n", message);
14             try {
15                 Thread.sleep(random.nextInt(5000));
16             } catch (InterruptedException e) {}
17         }
18         System.out.println("Consumer␣Exits");
19     }
20 }
```

Producer/Consumer Threads VI

```
1 //from Java Tutorial
2 public class ProducerConsumerExample {
3     public static void main(String[] args) {
4         Drop drop = new Drop();
5         (new Thread(new Producer(drop))).start();
6         (new Thread(new Consumer(drop))).start();
7     }
8 }
```