Konzepte objektorientierter Programmierung

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Exercises 10: Concurrency

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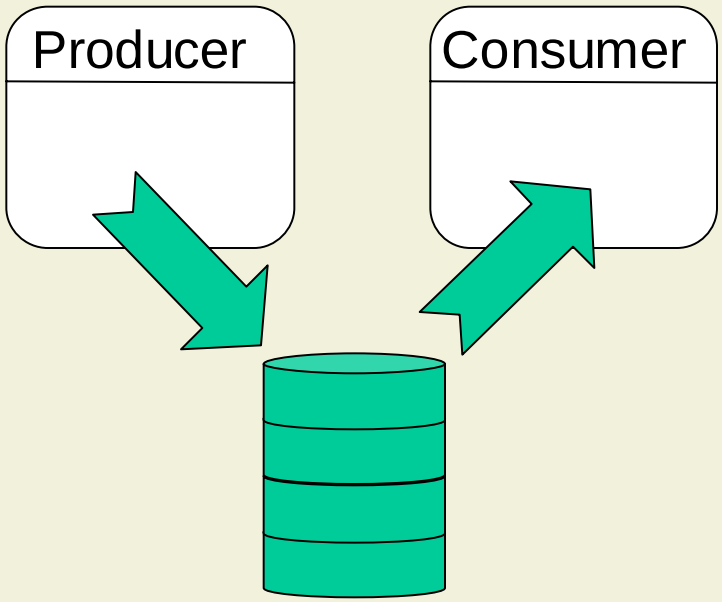
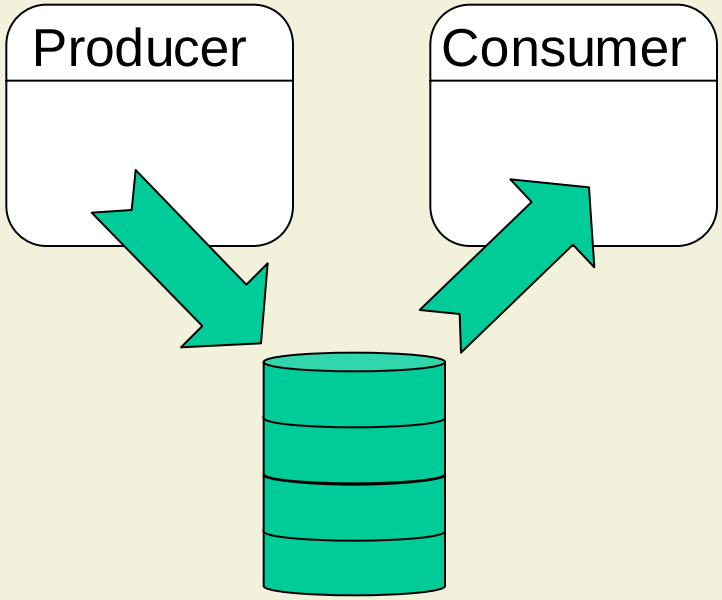
Cooperating Threads

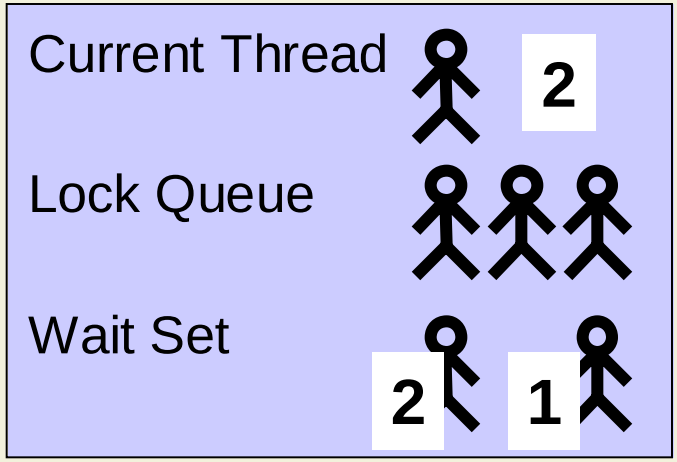
- One thread has to wait until another thread has performed an action
- Wait condition usually depends on commonly used variables (occurs inside synchronized methods)



Wait and Notify

- Wait operation
  - Can be applied if a thread has locked a monitor
  - Puts thread into wait state and adds thread to wait set
  - Releases lock
- Notify operation
  - Can be applied if a thread has locked a monitor
  - Chooses one thread from wait set and re-enables it for scheduling





Producer-Consumer Example Revisited

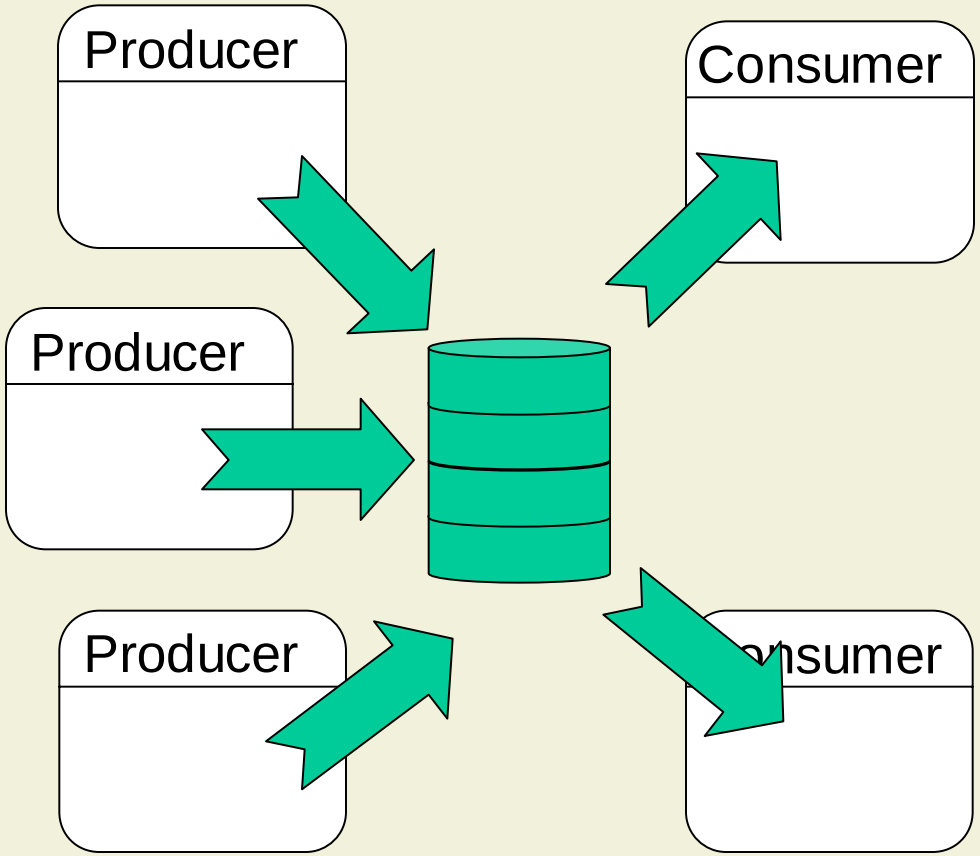
```
class Buffer {
  …
  synchronized void put( Prd p ) {
    if ( isFull( ) )                wait( );
    …
    notify( );
  }

  synchronized Prd get ( ) {
    if ( isEmpty( ) )    wait( );
    …
    notify( );
  }
}
```

```
class Producer extends Thread {
  Buffer buf;
  void run( ) {
    while ( true )
      buf.put( new Prd( ) );
  }
}
```

```
class Consumer extends Thread {
  Buffer buf;
  void run( ) {
    while ( true )
      buf.get( );
  }
}
```

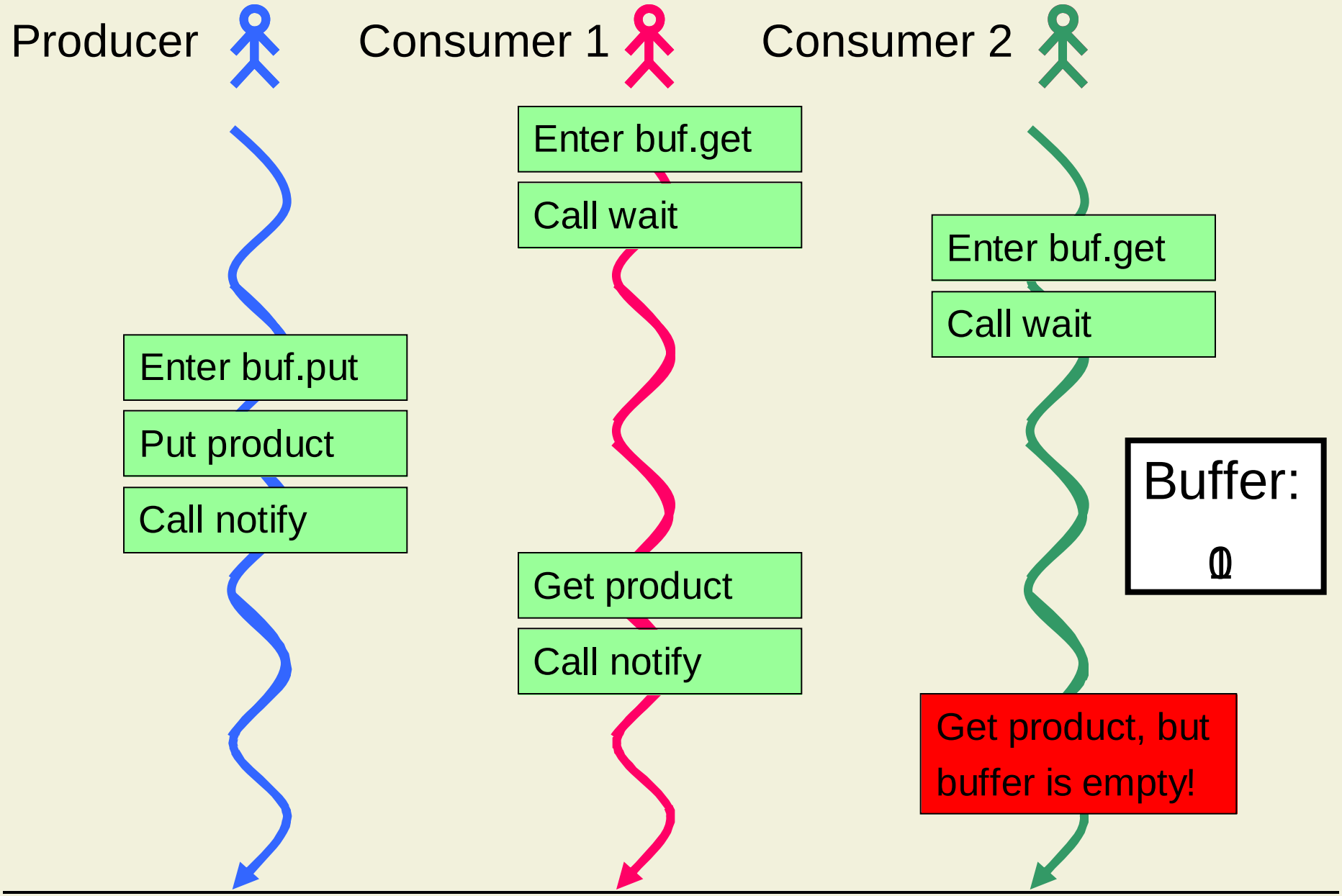
Multiple Producers & Consumers



Lazy Attempt: Reuse the Program

```
public synchronized void put( Prd p ) {
   if( isFull() ) {
      wait();
   }
   …
   notify();
}
```

2 Problems if there are more than 2 threads!

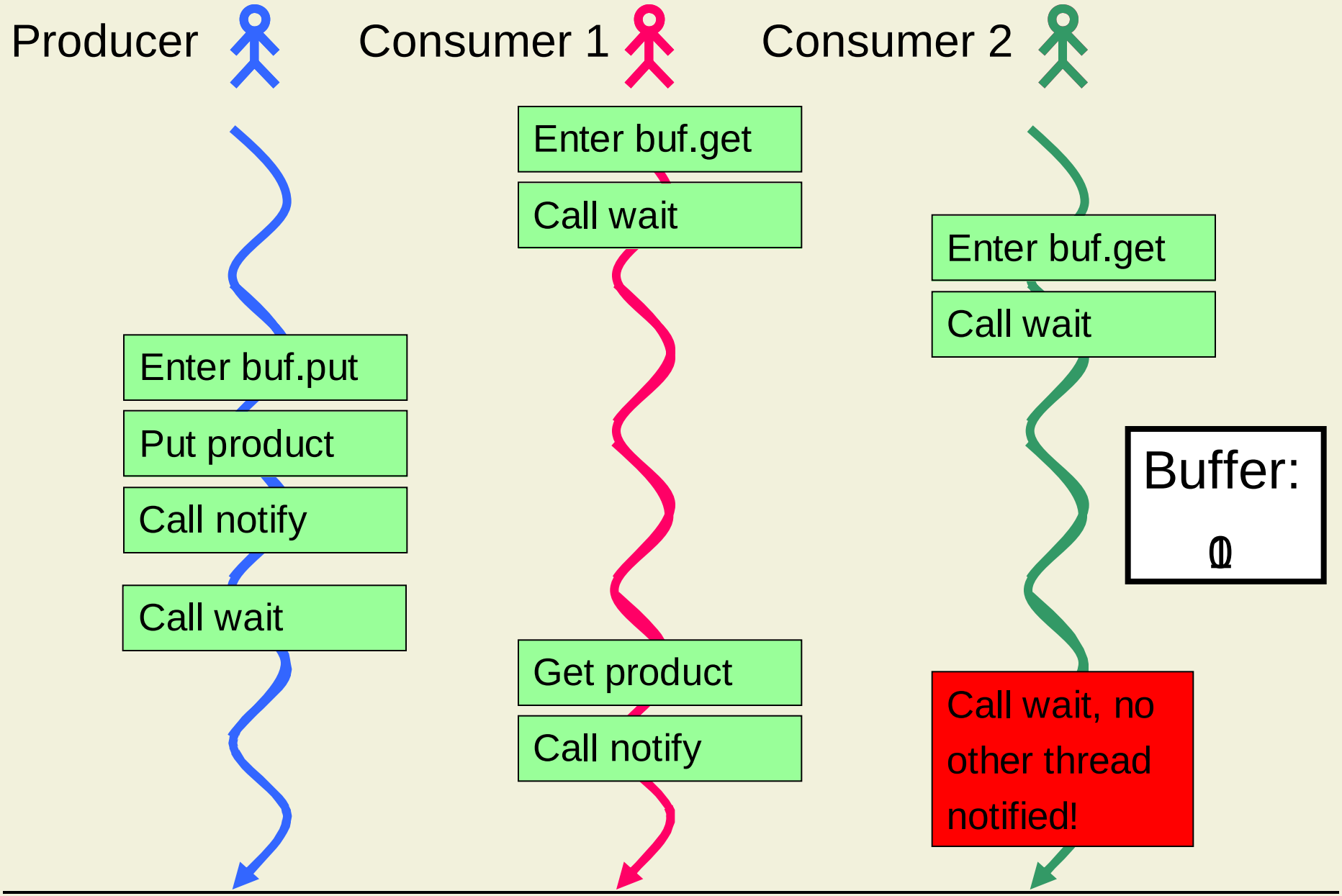


Lazy Attempt: Reuse the Program

```
public synchronized void put( Prd p ) {
   if( isFull() ) {
      wait();
   }
   …
   notify();
}
```

First Step

```
public synchronized void put( Prd p ) {
   while( isFull() ) {
      wait();
   }
   …
   notify();
}
```



Solution

```
public synchronized void put( Prd p ) {
   while( isFull() ) {
      wait();
   }
   …
   notifyAll();
}
```

Problem with notify

If there are multiple producers and consumers:

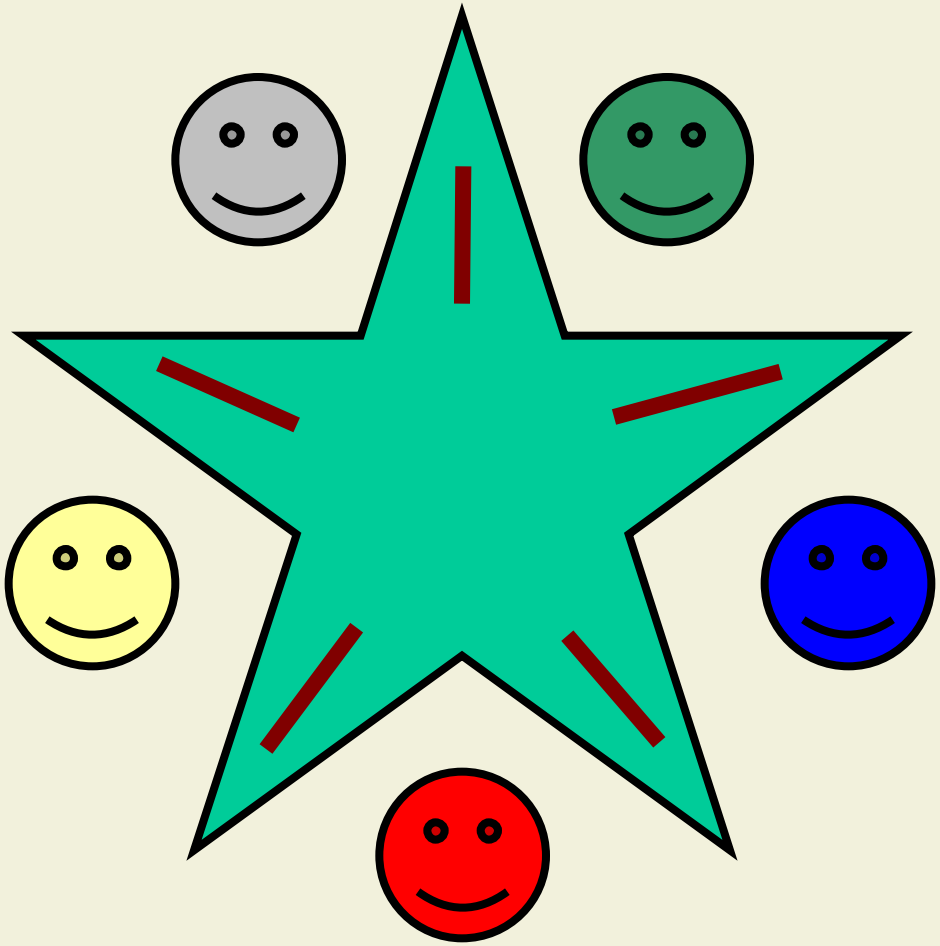
- All producers wait, b/c the buffer is full
- The buffer becomes empty and all consumers start to wait
- Some first producer A fills the buffer and then notifies another producer B
- That producer B sees a full buffer and waits
- Producer A sees a full buffer and waits

`notify` vs. `notifyAll`

- `java.lang.Object: final void notify()`
  Wakes up a single thread that is waiting on this object's monitor. If any threads are waiting on this object, one of them is chosen to be awakened. The choice is arbitrary and occurs at the discretion of the implementation. A thread waits on an object's monitor by calling one of the wait methods.
- `java.lang.Object: final void notifyAll()`
  Wakes up all threads that are waiting on this object's monitor. A thread waits on an object's monitor by calling one of the wait methods.

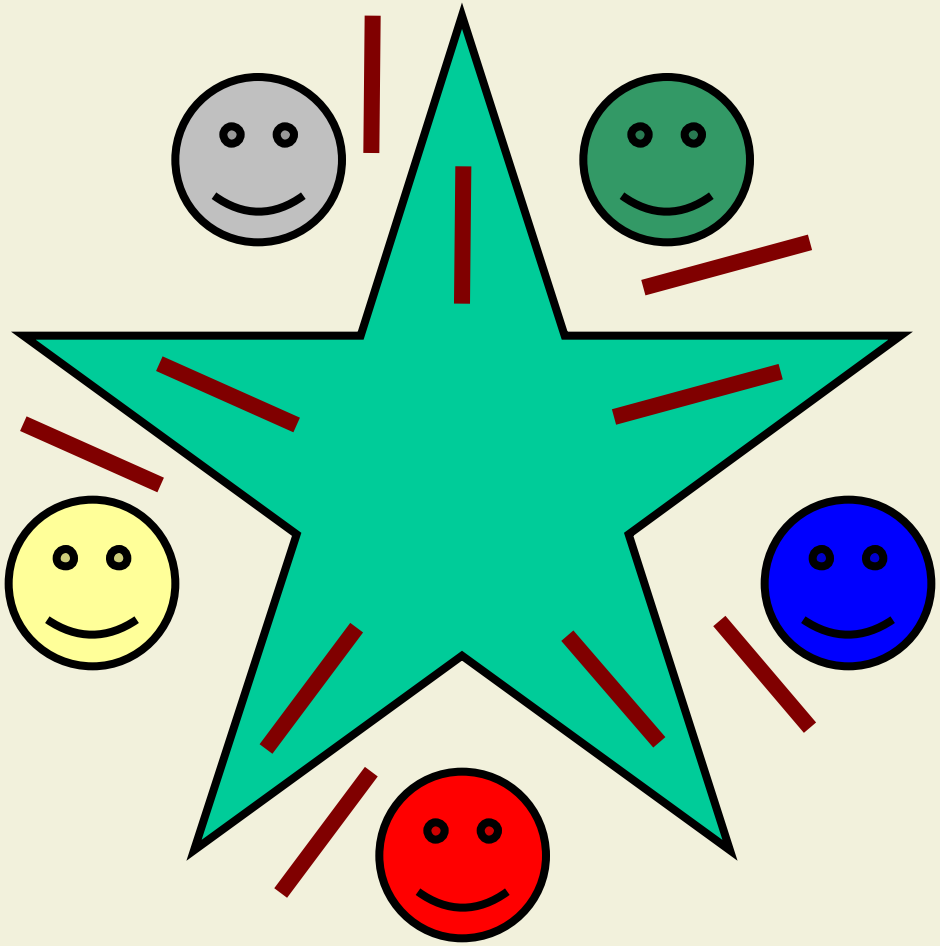
Dining Philosophers Problem

- n Philosophers
- n Chopsticks
- 2 Chopsticks needed for eating



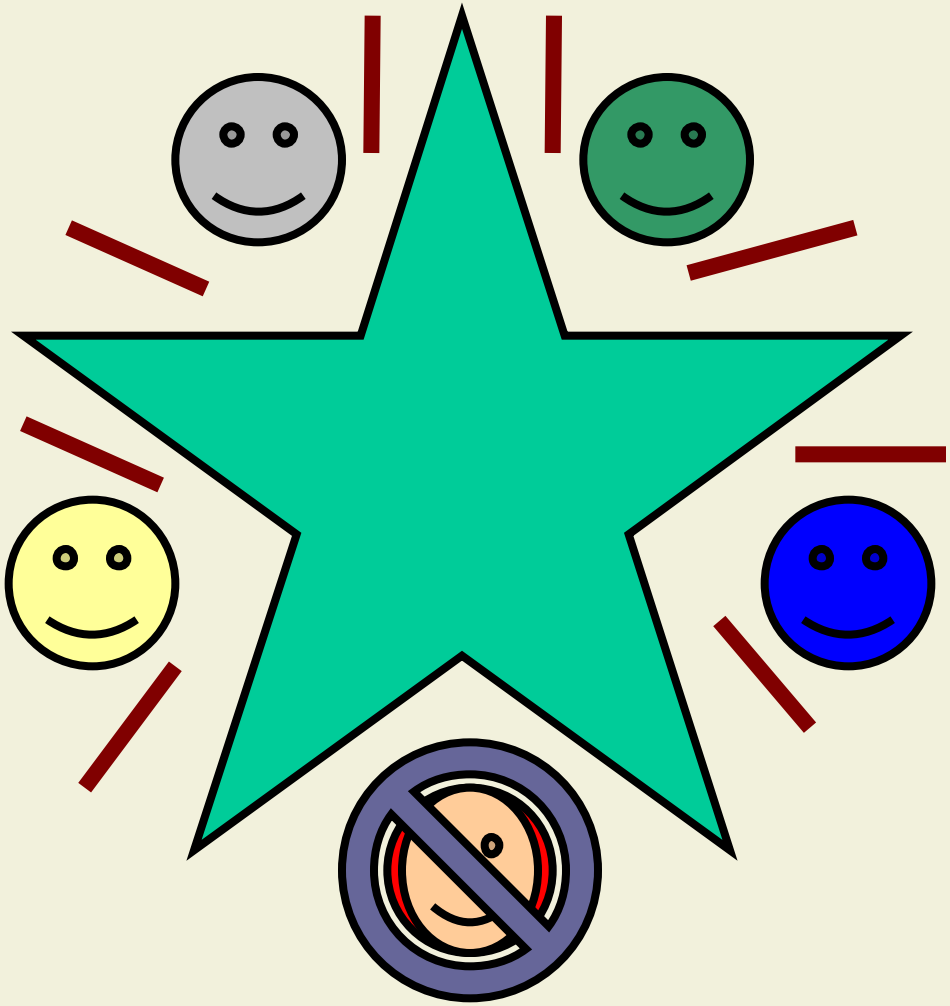
Problem: Deadlock

Everybody picks
the left chopstick
and then waits
forever to get
the right chopstick.



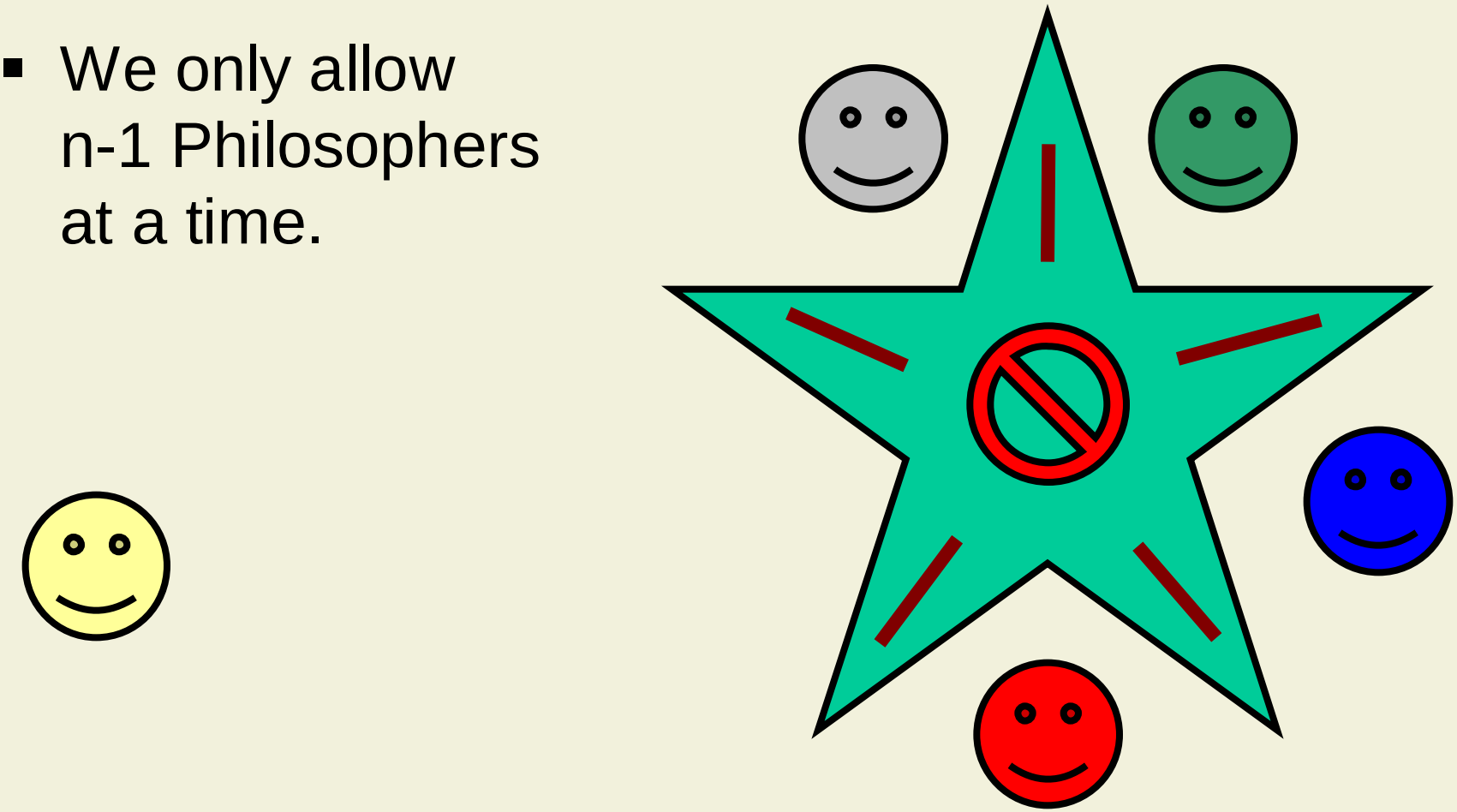
Problem: Starvation

Some philosophers Never get a chance to pick up both chopsticks and “starve”.



Solution 1: Central Control

- We only allow n-1 Philosophers at a time.



Solution 1: Der Philosoph

```
public class Philosoph extends Thread {
  public void run() {
    while( true ) {
      denken();

      t.anmelden(id);
      t.gabel[id].belegen(id);
      t.gabel[(id+1)%t.n].belegen((id+1)%t.n);

      essen();

      t.gabel[id].freigeben(id);
      t.gabel[(id+1)%t.n].freigeben((id+1)%t.n);
      t.abmelden(id);
    }
  }
}
```

Solution 1: Die Gabel

```
public class Gabel {
  public boolean belegt;

  public synchronized void belegen(int id) {
    if( belegt ) try { wait(); }
          catch( InterruptedException e ) {};
    belegt = true;
  }

  public synchronized void freigeben(int id) {
    belegt = false;
    notify();
  }
}
```

Solution 1: Der Tisch

```
public class Tisch {
  public Gabel[] gabel;
  private int phil;
  Philosoph[] phils;

  public synchronized void anmelden(int id) {
    if( phil >= n ) try { wait(); }
          catch( InterruptedException e ) {}
    phil = phil + 1;
  }

  public synchronized void abmelden(int id) {
    phil = phil - 1;
    notify();
  }
```

Solution 2: Ordered Resources

- We demand that the chopsticks are picked up in a specific order
- For one philosopher this means that he will pick up the right chopstick first
- The deadlock situation of all philosophers picking up the left chopstick at the same time is prevented

Solution 2: Der Philosoph

```
public void run() {
  int first, second;

  first = id < ((id+1)%t.n) ? id : (id+1)%t.n;
  second = id<((id+1)%t.n) ? (id+1)%t.n : id;

  while (true) {
     denken();
     t.gabel[first].belegen(first);
     t.gabel[second].belegen(second);


     essen();
     t.gabel[first].freigeben(first);
     t.gabel[second].freigeben(second);
  }
}
```

Solution 3: Atomic Operation

- We only allow both chopsticks to be picked up together
- Needs a critical section for the atomic operation
- Careful with what objects are used for synchronization

Solution 3: Die Gabel

```
public class Gabel {
  public boolean belegt;

  public Gabel() { belegt = false; }

  public synchronized void belegen(int id) {
      belegt = true;
  }

  public synchronized void freigeben(int id) {
      belegt = false;
  }
}
```

Solution 3: Der Philosoph

```
public void run() {
  while( true ) {
    denken();

    synchronized( t ) {
      while( t.gabel[id].belegt ||
             t.gabel[(id+1)%t.n].belegt ) {
        try { t.wait(); }
        catch( InterruptedException e ) {};
      }
      t.gabel[id].belegen(id);
      t.gabel[(id+1)%t.n].belegen((id+1)%t.n);
    }
```

Solution 3: Der Philosoph

```
    ...

    essen();

    synchronized( t ) {
      t.gabel[id].freigeben(id);
      t.gabel[(id+1)%t.n].freigeben((id+1)%t.n);

      t.notifyAll();
    }
  }
}
```