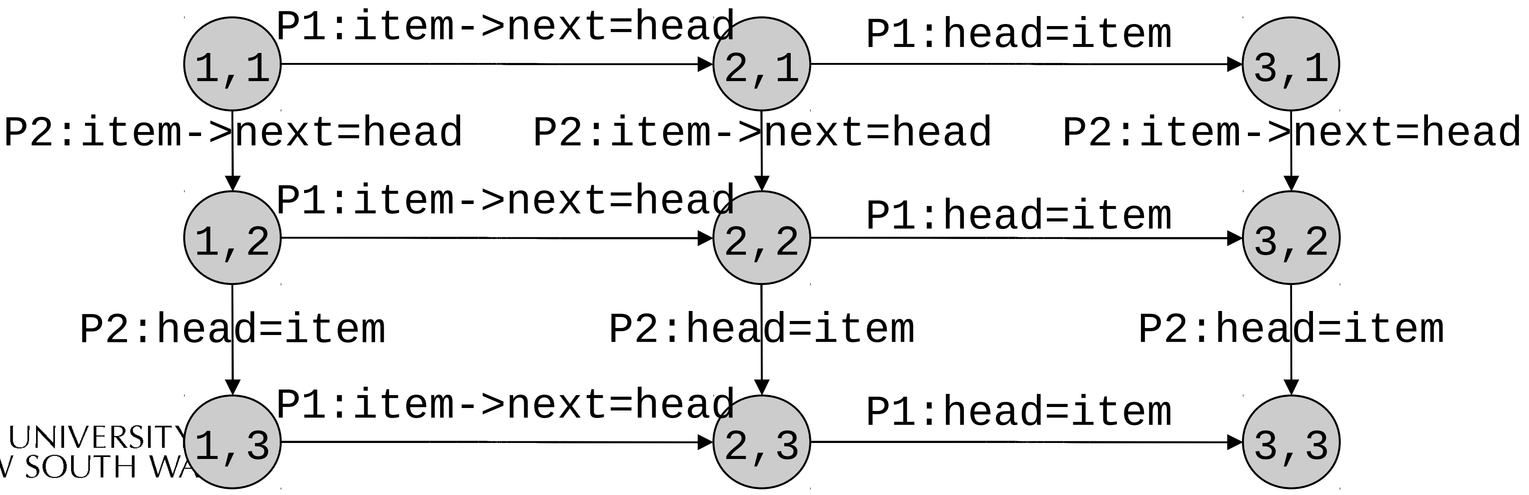
Question 1

- Race condition: the result of the computation depends on the relative speed of two or more processes
  - Occur non-deterministically
  - Hard to debug

```
void insert(struct node *item)
{
  item->next = head;
  head = item;
}
```

```
void insert(struct node *item)
{
  item->next = head;
  head = item;
}
```



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Question 2

```
void insert(struct node *item)
{
  item->next = head;
  head = item;
}
```

...

```
void insert(struct node *item)
{
  item->next = head;
  head = item;
}
```

N processes

- Question: How many states?
- 3^N

Question 3

```
while(TRUE) {
                                  while(TRUE) {
                                      while(lock == 1);
    while(lock == 1);
    lock = 1;
                                      lock = 1;
    critical();                       critical();
    lock = 0
    non_critical();
}                                     lock = 0
                                      non_critical();
                                  }
```

Question 4

- A uniprocessor system runs one thread at a time
- Concurrency arises from preemptive scheduling
- The scheduler is invoked on a timer interrupt
  - Disabling interrupts disables preemptive scheduling and guarantees atomicity

Question 5

```
void mutex_lock(bool* lock)
{
   if (test_and_set(lock) == 1)


      sleep();
}
```

```
void mutex_unlock(bool* lock)
{

   *lock = 0;
   wakeup();
}
```

- The `wakeup()` is lost

Question 6

```
int count = 0;
#define N 4 /* buf size */
prod() {
   while(TRUE) {
    item = produce()
    if (count == N)
        sleep();
    insert_item();
    count++;
    if (count == 1)
        wakeup(con);
   }
}
```

```
con() {
   while(TRUE) {
       if (count == 0)
           sleep();
       remove_item();
       count--;
       if (count == N-1)
           wakeup(prod);
   }
}
```

Concurrent uncontrolled access to the buffer

Question 6

```
int count = 0;
#define N 4 /* buf size */
prod() {
   while(TRUE) {
    item = produce()
    if (count == N)
        sleep();
    insert_item();
    count++;
    if (count == 1)
        wakeup(con);
   }
}
```

```
con() {
    while(TRUE) {
        if (count == 0)
            sleep();
        remove_item();
        count--;
        if (count == N-1)
            wakeup(prod);
    }
}
```

Concurrent uncontrolled access to the counter