61A Lecture 32

November 16th, 2011

Last time

Distributed systems
- Architectures
  - Client-server
  - Peer-to-peer
- Message passing
  - Protocols

System design principles
- Modularity
- Interfaces

Today: Parallel Computation

Why is parallel computation important?

What is parallel computation?

Some examples in Python

Some problems with parallel computation

Transistors

Computers execute instructions by manipulating the flow of electricity through **transistors.**

Transistors are made from semiconductors, like silicon.

More transistors = more power.

Transistors are now less than 100 nanometers in size.

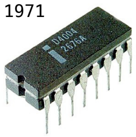
Microprocessor

Transistors are arranged into "integrated circuits" on single pieces of hardware.

A **microprocessor**, or **processor** is a large integrated circuit of transistors where a computer's instructions are executed.

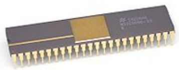
Microprocessors

1971



Intel 4000
2300 Transistors

1981



National Semiconductor NS3008
~10,00 Transistors

1993

Intel Pentium
~3 million transistors

2000's

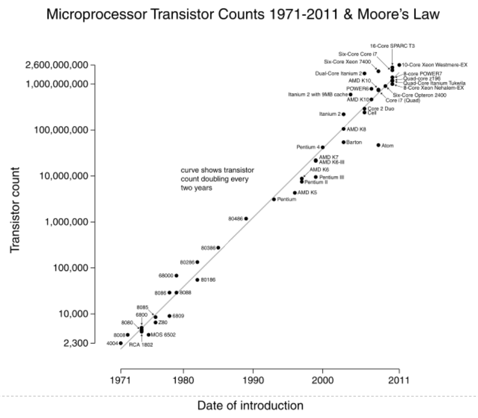
AMD 64
~243 million transistors

Moore's law

In 1965, the co-founder of Intel, Gordon Moore predicted that the number of transistors that could be fit onto a single chip would double every year.

46 years later, that prediction is still true.

More transistors every year


Microprocessor Transistor Counts 1971-2011 & Moore's Law

Physical limits

```
Manufacturers are reaching physical limits
   ▪ Transistors size limits
   ▪ Instructions speed limits
```

The solution: multiple microprocessors

```
Instead of trying to fit more transistors into a single
processor, we are turning to multiple processors.
```

Parallel Computation

```
A program (a set of instructions, a piece of code)

Executed simultaneously by multiple processors

In a shared memory environment
```

Parallel computing example

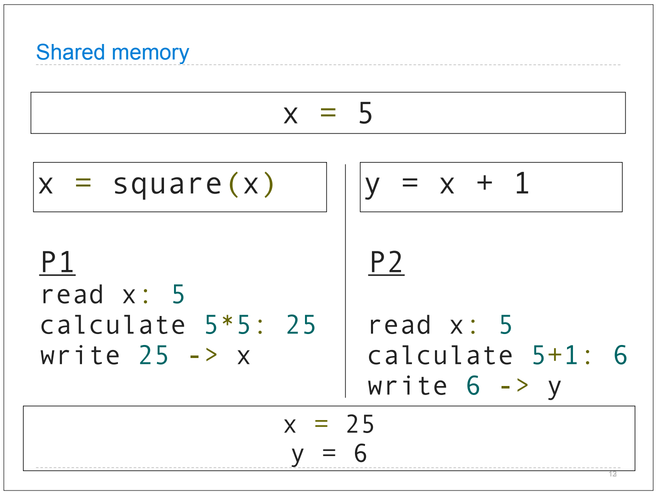
```
x = 5
x = square(x)
y = 6
y = y+1

write 5 -> x
read x: 5
calculate 5*5: 25
write 25 -> x
write 6 -> y
read y: 6
calculate 6+1: 7
write y-> 7
```

Parallel computing example

```
x = 5
x = square(x)
y = 6
y = y+1

read x: 5
calculate 5*5: 25
write 25 -> x
read y: 6
calculate 6+1: 7
write y-> 7
```

Parallel computing example

```
x = 5                   y = 6
x = square(x)           y = y+1


P1                      P2
write 5 -> x            write 6 -> y
read x: 5               read y: 6
calculate 5*5: 25       calculate 6+1: 7
write 25 -> x           write 7 -> y

              x = 25
               y = 7
```



Shared memory

```
x = 5

x = square(x)          y = x + 1

P1                     P2
read x: 5
calculate 5*5: 25      read x: 5
write 25 -> x          calculate 5+1: 6
                       write 6 -> y

x = 25
y = 6
```

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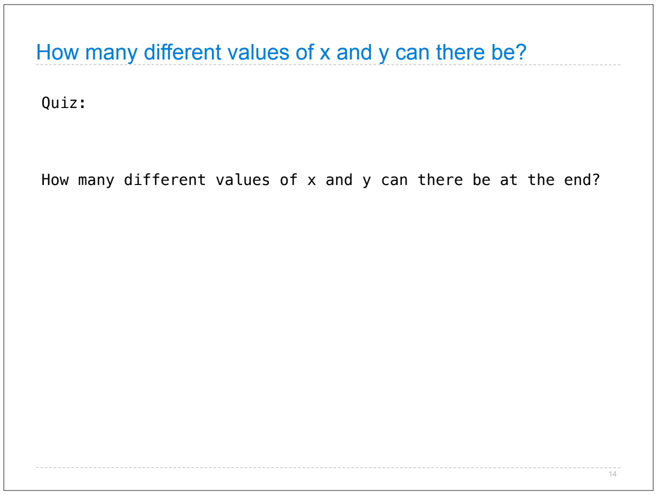

How many different values of x and y can there be?

Quiz:

How many different values of x and y can there be at the end?

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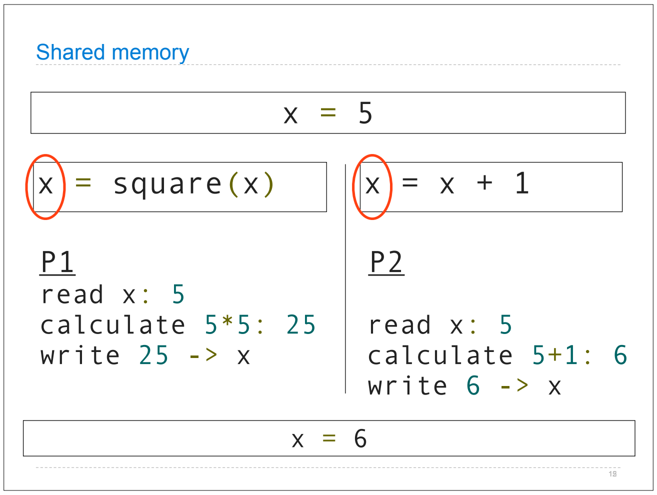

Shared memory

```
x = 5

x = square(x)          x = x + 1

P1                     P2
read x: 5
calculate 5*5: 25      read x: 5
write 25 -> x          calculate 5+1: 6
                       write 6 -> x

x = 6
```

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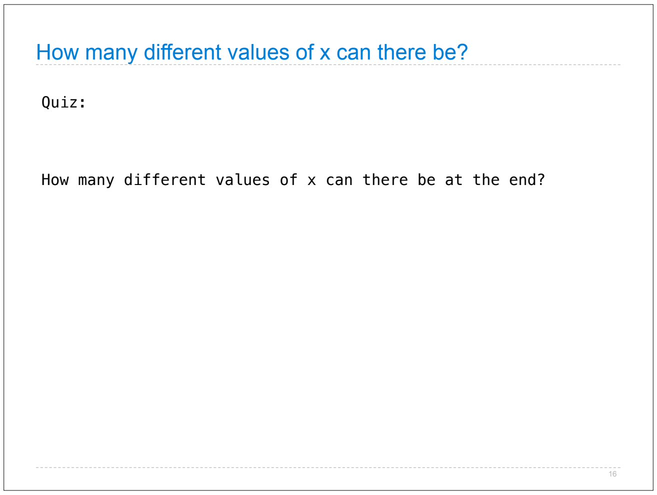

How many different values of x can there be?

Quiz:

How many different values of x can there be at the end?

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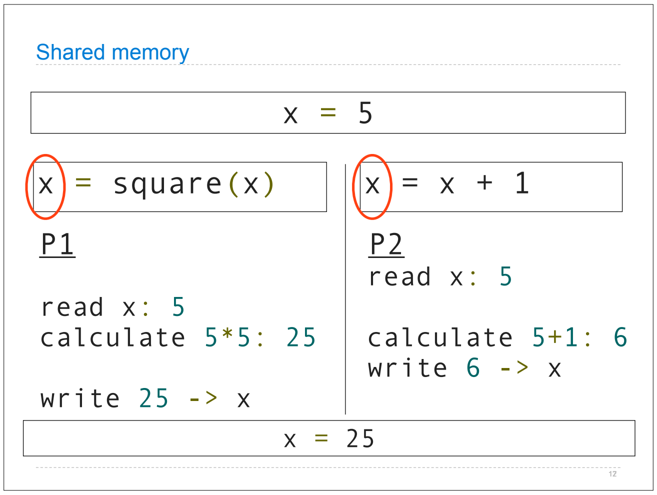

Shared memory

```
x = 5

x = square(x)          x = x + 1

P1                     P2
                       read x: 5
read x: 5
calculate 5*5: 25      calculate 5+1: 6
                       write 6 -> x
write 25 -> x

x = 25
```

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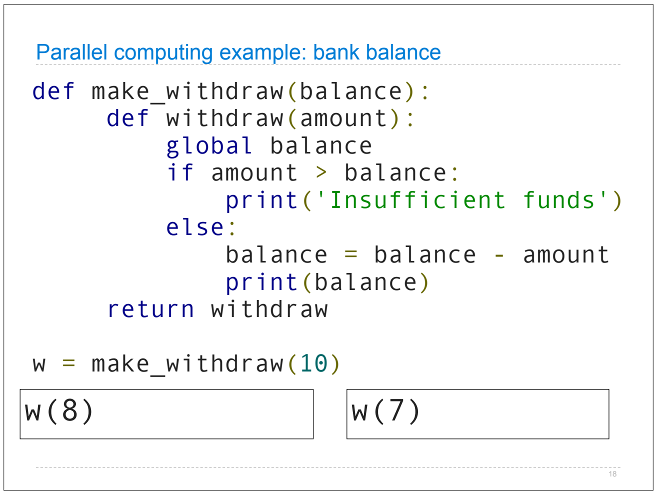

Parallel computing example: bank balance

```
def make_withdraw(balance):
    def withdraw(amount):
        global balance
        if amount > balance:
            print('Insufficient funds')
        else:
            balance = balance - amount
            print(balance)
    return withdraw

w = make_withdraw(10)
```

```
w(8)          w(7)
```

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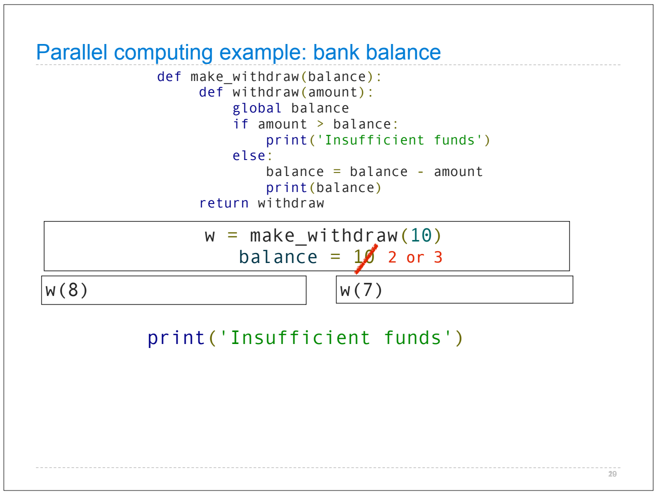

Parallel computing example: bank balance

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        else:
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            print(balance)
    return withdraw
```

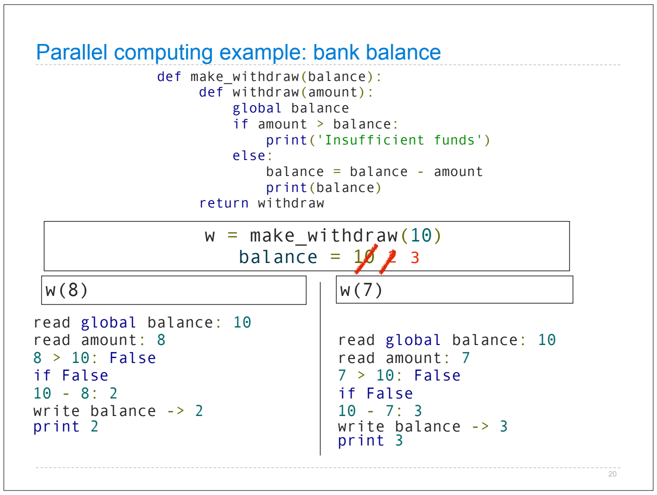
```
w = make_withdraw(10)
```

balance = ~~10~~ 2 or 3

```
w(8)
```

```
w(7)
```

```
print('Insufficient funds')
```



Parallel computing example: bank balance

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    def withdraw(amount):
        global balance
        if amount > balance:
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        else:
            balance = balance - amount
            print(balance)
    return withdraw
```
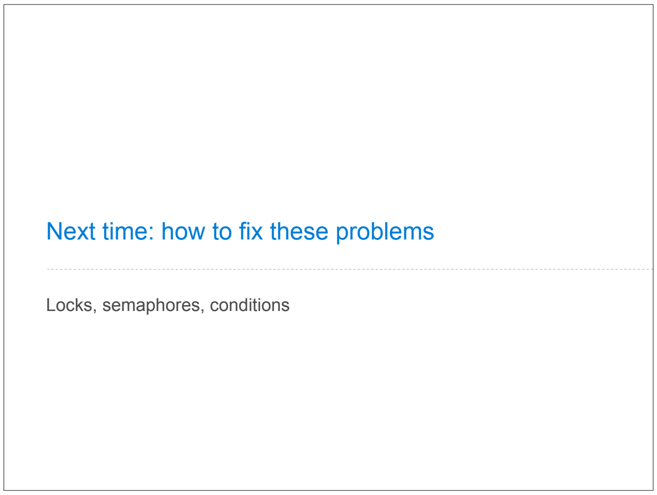

```
w = make_withdraw(10)
```

balance = ~~10~~ ~~2~~ 3

```
w(8)
read global balance: 10
read amount: 8
8 > 10: False
if False
10 - 8: 2
write balance -> 2
print 2
```

```
w(7)
read global balance: 10
read amount: 7
7 > 10: False
if False
10 - 7: 3
write balance -> 3
print 3
```



Next time: how to fix these problems

Locks, semaphores, conditions