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

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

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

\[
\begin{align*}
  x &= 5 \\
  x &= \text{square}(x) \\
  y &= 6 \\
  y &= y+1 \\
  \text{write } 5 \rightarrow x \\
  \text{read } x: 5 \\
  \text{calculate } 5\times5: 25 \\
  \text{write } 25 \rightarrow x \\
  \text{read } y: 6 \\
  \text{calculate } 6+1: 7 \\
  \text{write } y\rightarrow 7
\end{align*}
\]
**Shared memory**

\[
x = 5
\]

\[
x = \text{square}(x) \quad \quad y = x + 1
\]

**P1**
- read x: 5
- calculate 5*5: 25
- write 25 -> x

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

\[
x = 25 \quad \quad y = 6
\]

**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?**


**Shared memory**

\[
x = 5
\]

\[
x = \text{square}(x) \quad \quad x = x + 1
\]

**P1**
- read x: 5
- calculate 5*5: 25
- write 25 -> x

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

\[
x = 6
\]

**How many different values of x can there be?**

**Quiz:**

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


**Shared memory**

\[
x = 5
\]

\[
x = \text{square}(x) \quad \quad x = x + 1
\]

**P1**
- read x: 5
- calculate 5*5: 25
- write 25 -> x

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

\[
x = 25
\]

**Parallel computing example: bank balance**

```python
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)
```
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

    w = make_withdraw(10)
    balance = 10
    w(8)
    w(7)
    print('Insufficient funds')

Next time: how to fix these problems

Locks, semaphores, conditions