CS10
The Beauty and Joy of Computing

Lecture #11 : Recursion II

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Security Flaws in your OS

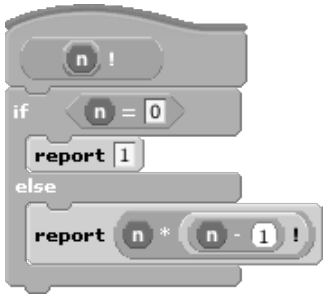
Nations and companies are paying hackers to expose bugs in their systems. Cyberwar, piracy, espionage, and privacy concerns abound.

http://www.nytimes.com/2013/07/14/world/europe/nations-buying-as-hackers-sell-computer-flaws.html?pagewanted=all

How the Computer Works … n!

- **Factorial(n) = n!**
- **Informal Definition**
  n! = [1 * 2 * 3 * … * n]
- **Inductive Definition**

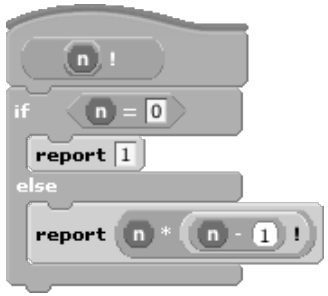
$$n! = \begin{cases} 1 & \text{, if } n = 0 \\ n * (n-1)! & \text{, if } n > 0 \end{cases}$$



How the Computer Works … n!

- **Let's act it out…**
  - **subcontractor model**
- **5!**

n	n!
0	1
1	1
2	2
3	6
4	24
5	120



Order of growth of # of calls of n!

a) Constant
b) Logarithmic
c) Linear
d) Quadratic
e) Exponential

(source: FallingFifth.com)

en.wikipedia.org/wiki/Fibonacci_number
www.ics.uci.edu/~eppstein/161/960109.html

Fibonacci

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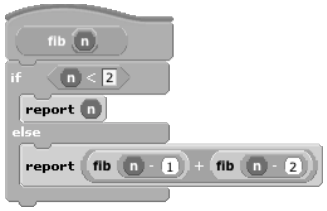
How the Computer Works … fib(n)

- **Inductive definition**

$$fib(n) = \begin{cases} n & , n < 2 \\ fib(n-1)+fib(n-2), & n > 1 \end{cases}$$

- **Let's act it out…**
  - **subcontractor model**
  - **fib(3)**

n	fib(n)
0	0
1	1
2	1
3	2
4	3
5	5



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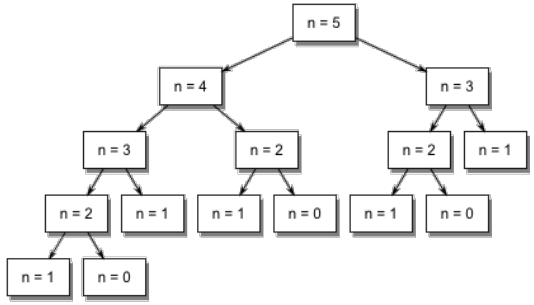
How the Computer Works … fib(n)



Order of growth of # of calls of fib(n)

a) Constant
b) Logarithmic
c) Linear
d) Quadratic
e) Exponential

Chimney of Turku Energia, Turku, Finland featuring Fibonacci sequence in 2m high neon lights. By Italian artist Mario Merz for an environmental art project. (Wikipedia)

Counting Change (thanks to BH)

- Given coins {50, 25, 10, 5, 1} how many ways are there of making change?
  - 5
    - 2 (N,5 P)
  - 10
    - 4 (D, 2N, N 5P, 10P)
  - 15
    - 6 (DN,D5P,3N,2N5P, 1N10P,15P)
  - 100?

Counting Change (thanks to BH)

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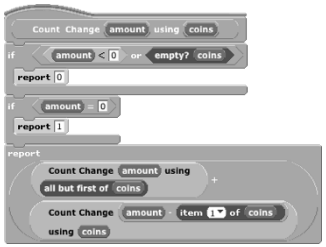
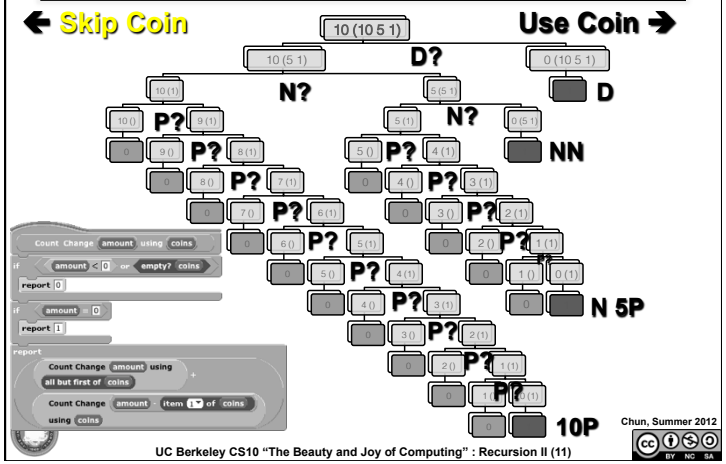


Call Tree for "Count Change 10 (10 5 1)"



Summary

- It's important to understand the subcontractor model
- It's often the cleanest, simplest way to solve many problems
  - Especially those recursive in nature!
- Recursion is a very powerful idea, and one way to separate good from great

Menger Cube by Dan Garcia