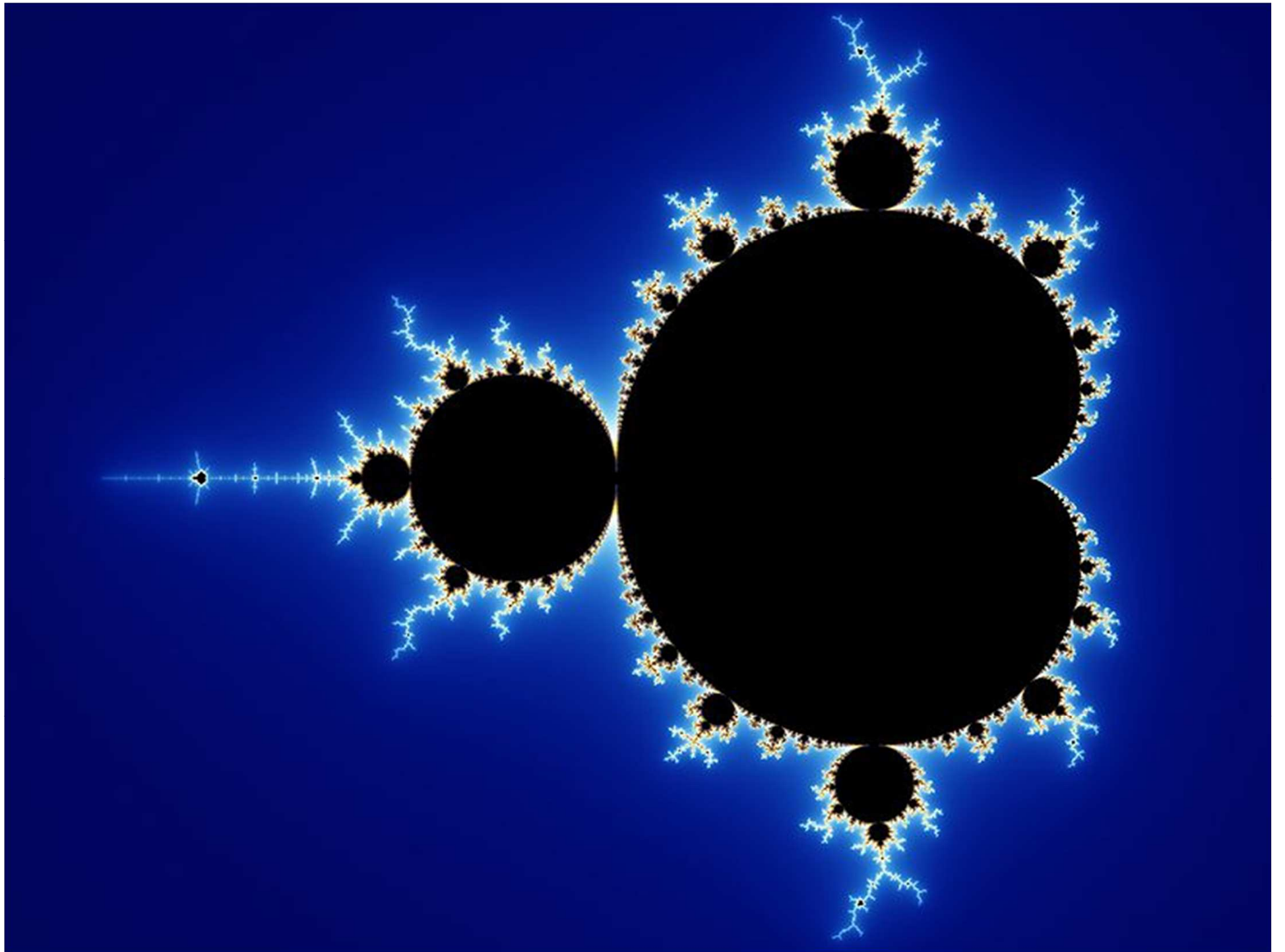
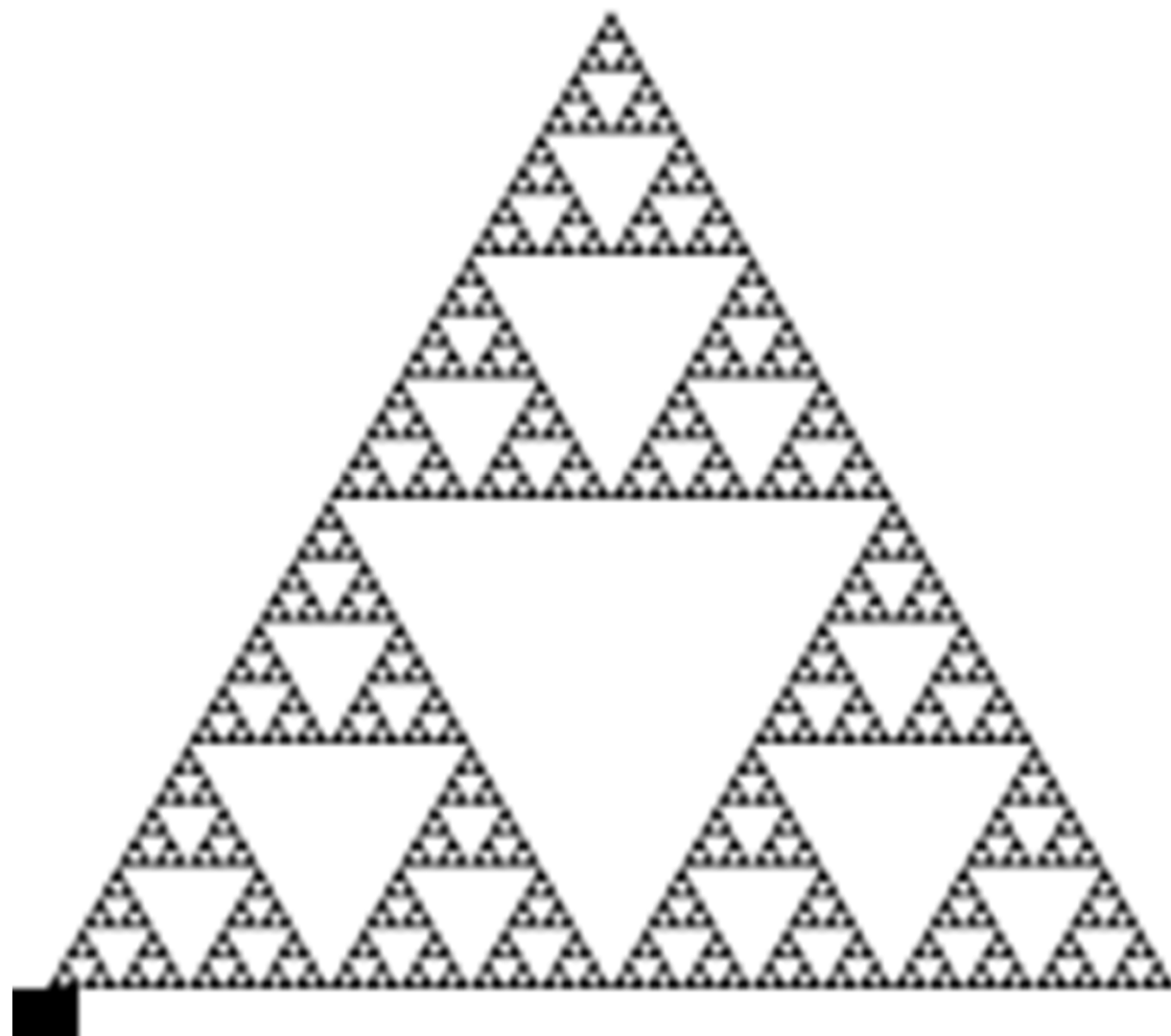


Good
morning!







Recursive Algorithms

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Example: Gift box!



Example: Gift box!



Example: Gift box!

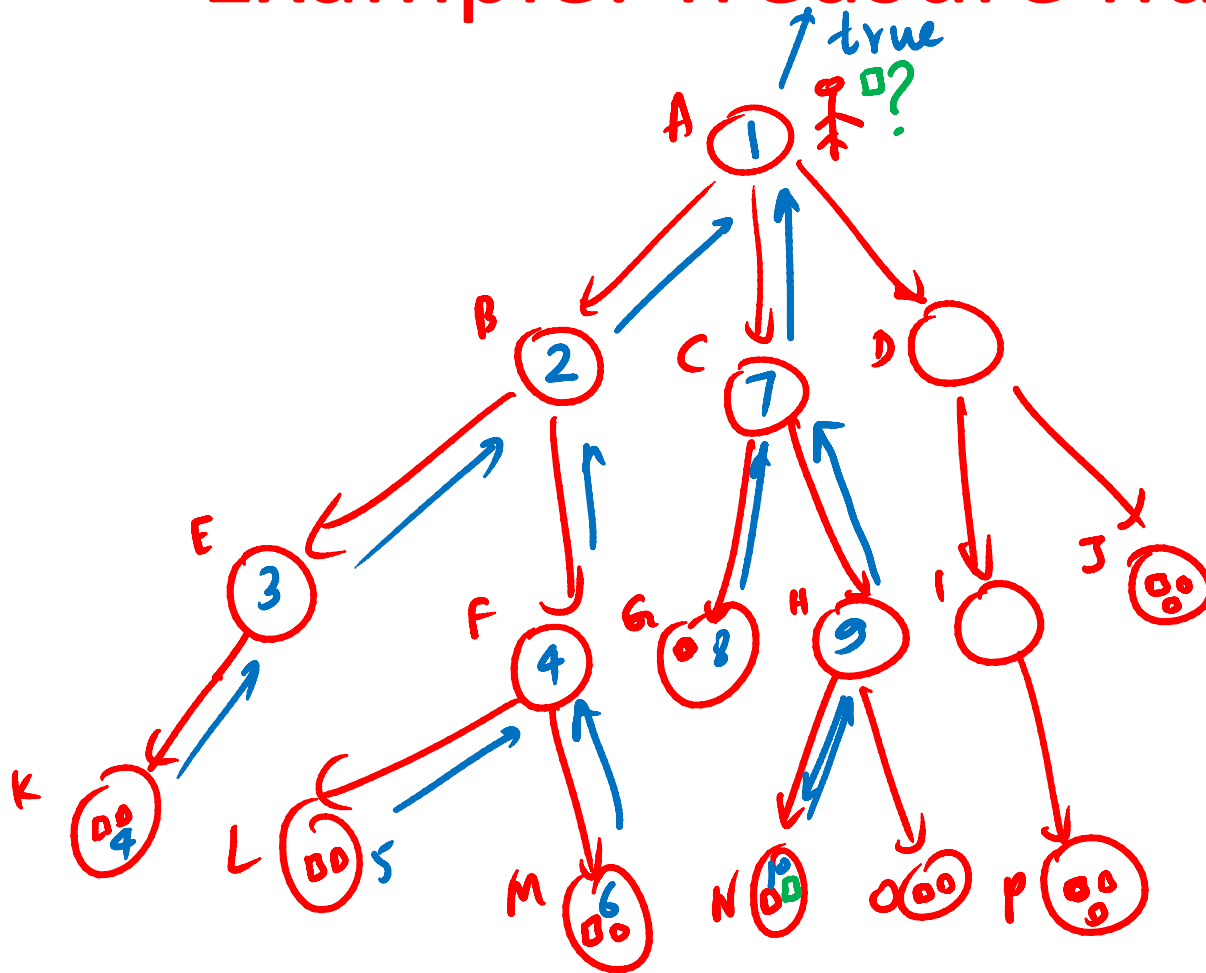


$value(box) = phone's\ price + watch\ price$

$+ value(box1) + value(box2) + value(box3);$

Value of gift box : Equation?

Example: Treasure hunt!



What is recursion?

- Popular in math definitions
- Inductive proof

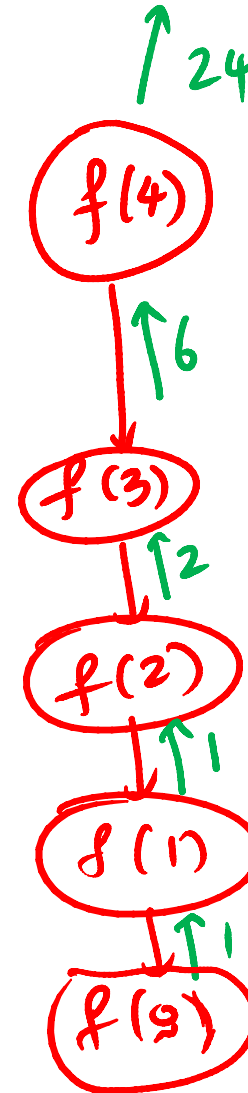
Example: factorial(n)

$$f(n) = 1 \quad \text{if } n=0$$
$$= n \times f(n-1) \quad \text{otherwise}$$

n	f(n)
0	1
1	1
2	2
3	6
4	24
5	120

$$1 \times f(0)$$

$$4 \times f(3)$$



Example: factorial(n)

- Non-recursive solution

How does recursion work?

- Stack memory
- How much stack memory is needed?

How to understand recursion?

- Method invocations & returns diagram
- Example: factorial(5)

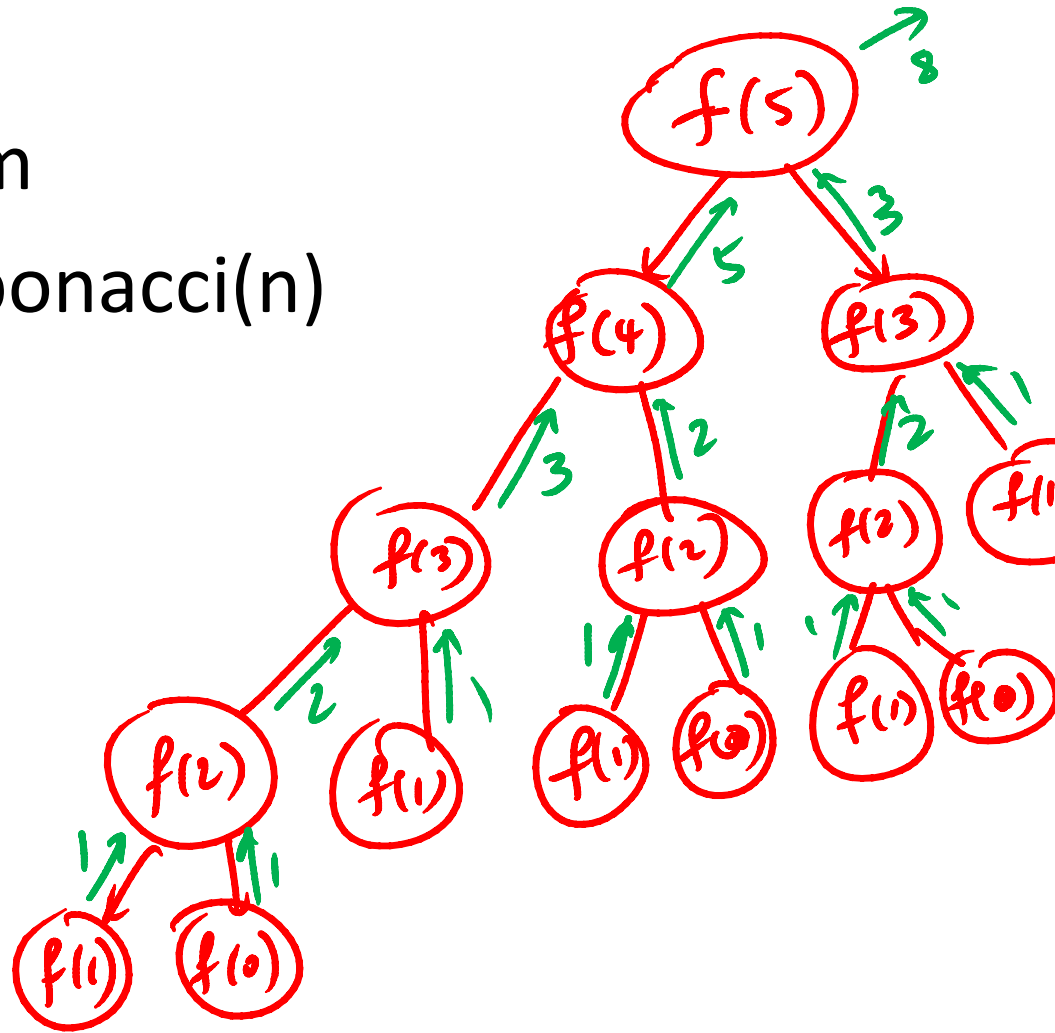
How to understand recursion?

- Method invocations & returns diagram

- Example: fibonacci(n) = 1 if $n < 2$
= fib...($n-1$) + fib...($n-2$)
otherwise.

How to understand recursion?

- Tree diagram
- Example: fibonacci(n)



non
rec
idea

0	1
1	1
2	2
3	3
4	5
5	8
6	13
	⋮
n	

fibonacci(n) : non-recursive solution?

How to analyze recursion?

- Recurrence relation & Time complexity

Example: Hanoi tower

Example: Fractals



Von_Koch_curve.gif

Petrol cost minimization problem

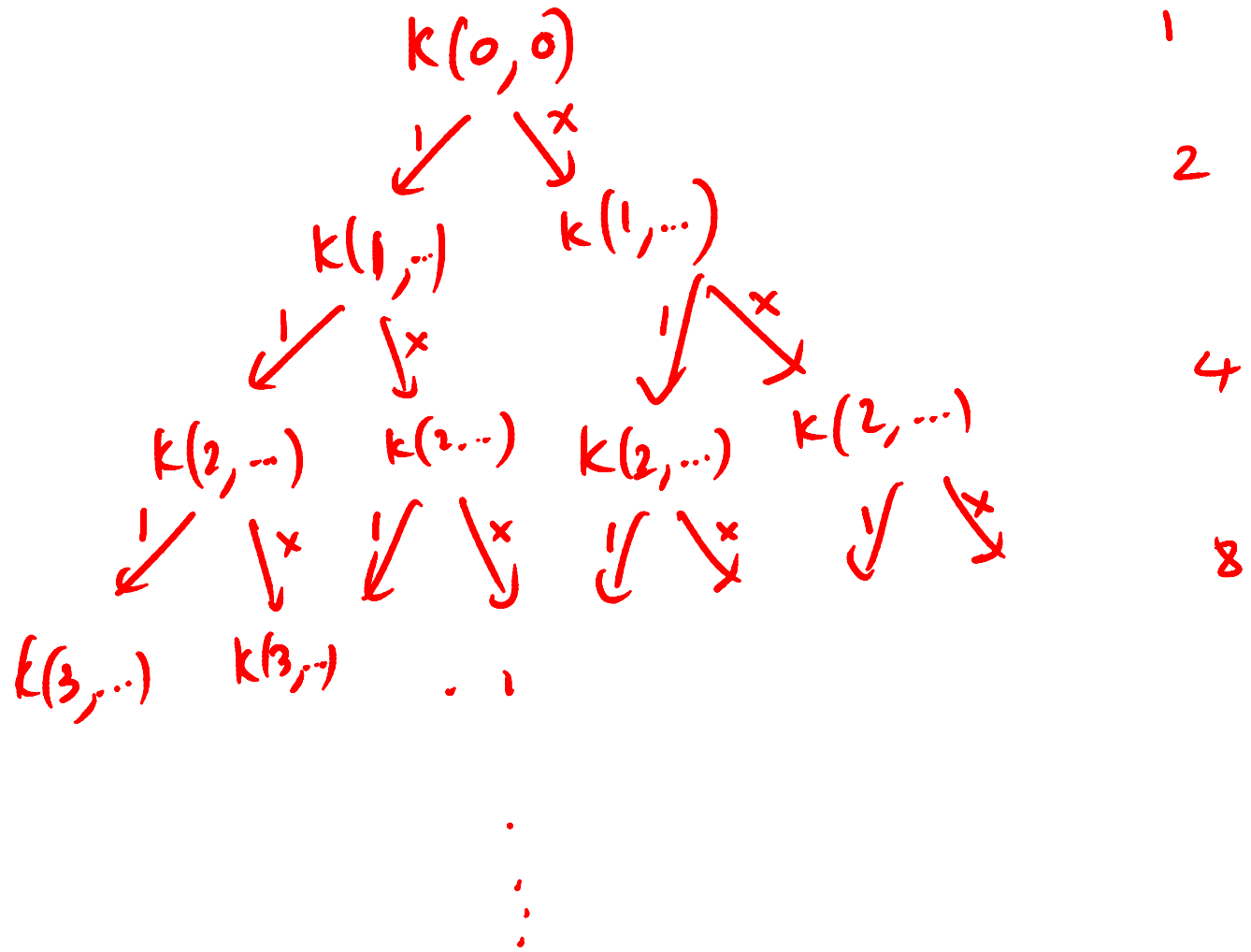
Similar solution: Quick-sort

Quick-sort: non-recursive solution?

Similar solution: Merge-sort

Example: Knapsack problem

- Item weights: 40, 10, 46, 23, 22, 16, 27, 6
- Instance #1: Target : 50
- Instance #2: Target: 60
- Instance #3: Target: 70



$k(n-1, \dots)$

$$\frac{2^{n-1}}{2^n - 1}$$

How to make recursion efficient?

- Parameters
- Tail recursion

Example: N-Queens puzzle

Example: Knight's tour

Example: Sudoku's puzzle

Example: Maximizing total conviviality

Conclusions

- Recursion is one of the difficult concepts to understand, perhaps it is not that intuitive.
- As per a few mathematicians & CS folks, it is one of the most beautiful concepts!
- While it is not used much in commercial applications, it certainly puts your logical thinking skills to work!
- It is easy to remove tail recursion, but all others are lot harder to remove.

Questions & Answers?