DATA STRUCTURES & ALGORITHMS

Recursion

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Recurrence

Basic objective

- When we have a bigger problem whose solution is complex.
- We decompose the problem into smaller units until we reach to the smallest sub-problem (base case) for which a solution is known.
- Then go back in reverse order and build upon the solutions of the sub-problems.

Recursion

A well defined mathematical function in which the function being defined is applied within its own definition.

Recursive Functions

- Function may call itself
- Function may call other Function and
- the other function in turn again may call the calling Function

Direct & indirect Recursion

Recursion is said to be *direct* when functions calls *itself* directly and is said to be *indirect* when it calls *other function* that in turn calls it

Other Types

Linear recursion : makes at most one recursive call each time it is invoked.

Binary recursion : makes two recursive calls.

Multiple recursion : method may make (potentially more than two) recursive calls.

Finding a recursive solution

- Each successive recursive call should bring you closer to a situation in which the answer is known
- A case for which the answer is known (and can be expressed without recursion) is called a base case
- Each recursive algorithm must have at least one base case, as well as the general recursive case

Recursion vs. Iteration

The factorial of a positive integer

For example, 4! = 4·3·2·1 = 24.

Iterative Solution

$$n! = \begin{cases} 1 & \text{if } n = 0 \\ n \cdot (n-1) \cdot (n-2) \cdots 3 \cdot 2 \cdot 1 & \text{if } n \geq 1 \end{cases}$$

Recursive Solution

$$\text{factorial}(n) = \begin{cases} 1 & \text{if } n = 0 \\ n \cdot \text{factorial}(n-1) & \text{if } n \geq 1 \end{cases}$$

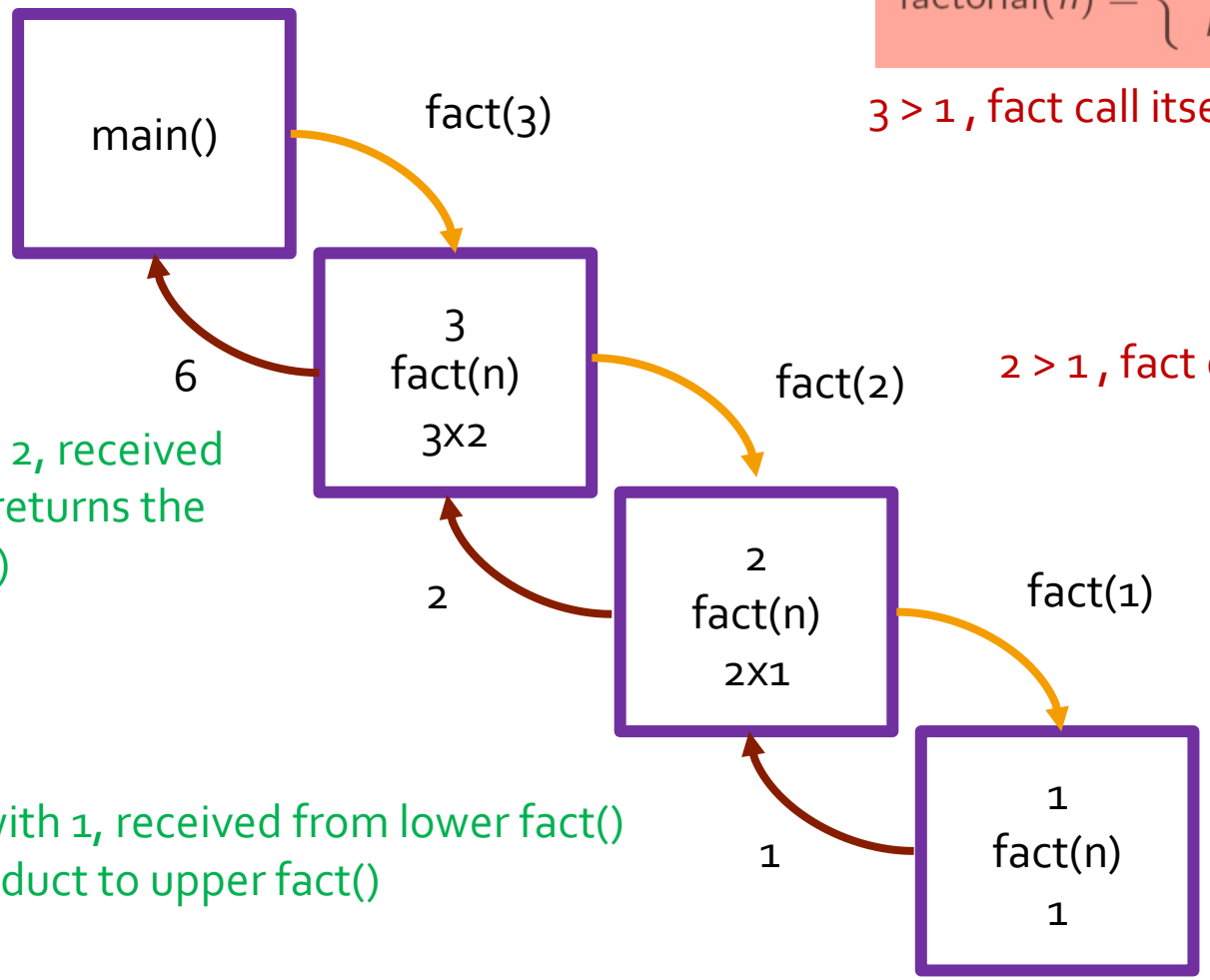
Example

Factorial of n

$$\text{factorial}(n) = \begin{cases} 1 & \text{if } n = 0 \\ n * \text{factorial}(n-1) & \text{if } n \geq 1 \end{cases}$$

Example - Factorial

$$\text{factorial}(n) = \begin{cases} 1 & \text{if } n = 0 \\ n * \text{factorial}(n-1) & \text{if } n \geq 1 \end{cases}$$



3 > 1 , fact call itself

2 > 1 , fact call itself

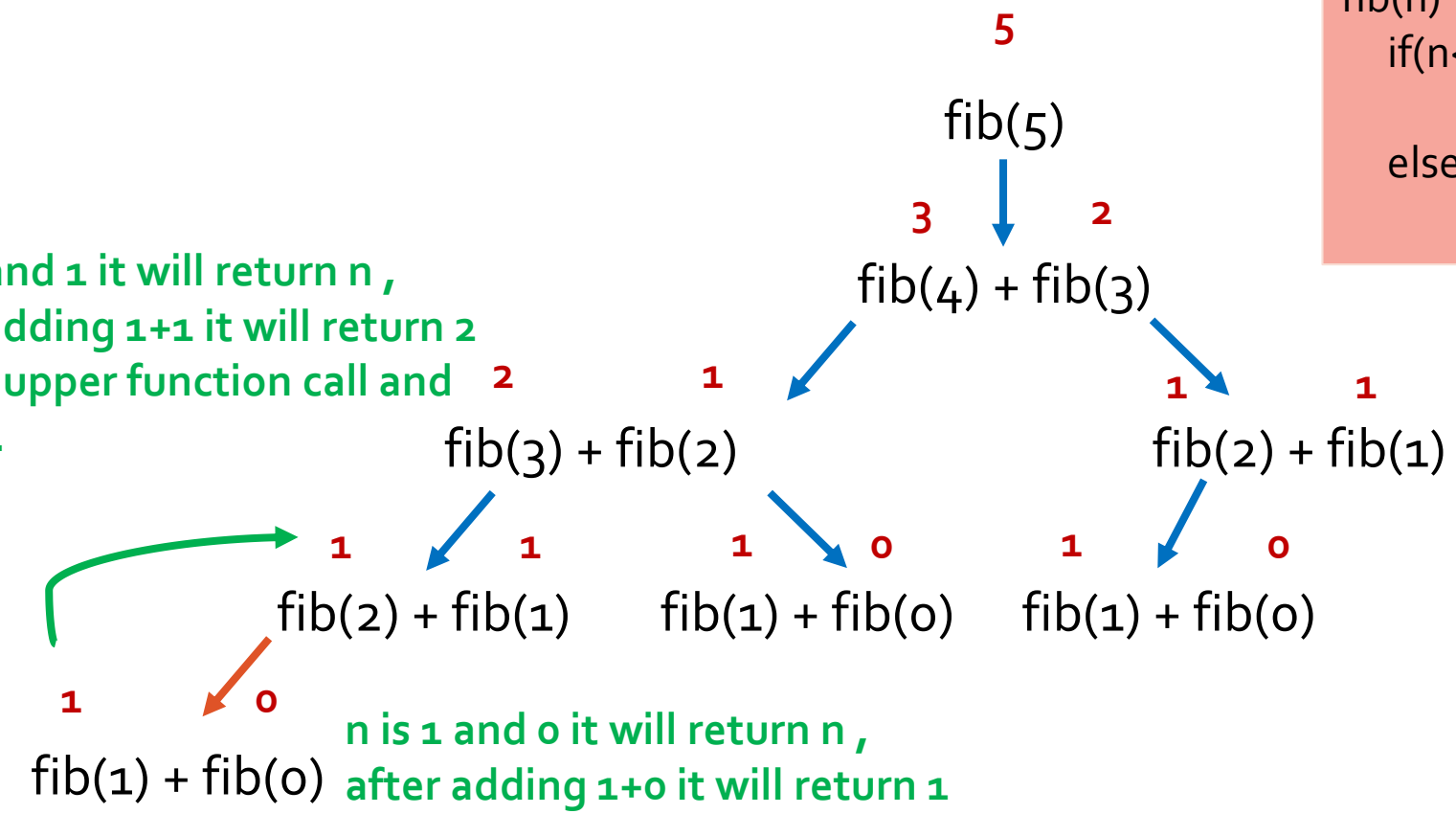
n=1, returns 1

fact() multiplies 3 with 2, received from lower fact() and returns the product to upper fact()

fact() multiplies 2 with 1, received from lower fact() and returns the product to upper fact()

Example Fibonacci Series

```
fib(n)
    if(n<2)
            return n
    else
            return ( fib(n-1) + fib(n-2) )
```



n is 1 and 1 it will return n , after adding 1+1 it will return 2 to the upper function call and so on..

n is 1 and 0 it will return n , after adding 1+0 it will return 1 to the upper function call

Run time stack tracing

Consider the function

```
int f(int x) {
  int y;
  if(x==0)
            return 1;
            else {
            y = 2 * f(x-1);
            return y + 1;
            }
     }
```