Introduction to computer programming with python

Lecture 10

Fall Semester, 2023

Contents

- Functions recap
- recursion

Functions - recap

See selection sort using list mutability and global scope under ‘functionsEGs.py’

Recursion

Recursion is the process of repeating items in a self-similar way

i.e., Reducing a problem into a smaller version of the same problem

Recursion

Algorithmically: Designing solution by ‘divide and conquer’ strategy
By reducing a problem to a simpler version of the same problem

Semantically: a programming technique where a function calls itself

- The goal is to obtain final solution, and avoid infinite recursion
- The sub-problem must have 1 or more base cases that are easy to solve
- Solve the same problem on other input, to simplify the bigger problem

Iterative Algorithms

Looping constructs (while/for loops) are **iterative algorithms**

Iterative algorithms perform repeated computation on a set of state variables through loop operations

Example: calculate multiplicity
a*b = a+a+a…+a (b times)

```python
def mult_fun(a,b):
    res = 0
    while b>0:
        res +=a
        b-=1
    return res
print(mult_fun(10,6))
```

Recursive Algorithms

Example: calculate multiplicity

a*b = a + a + a… + a (b times)
= a + (a + a… +a) (b-1 times)
= a + a*(b-1)

Recursive step:
Reduce the problem to a simpler/smaller version of the same problem

= a + $\boxed{a*(b-1)}$ ← Recursive reduction

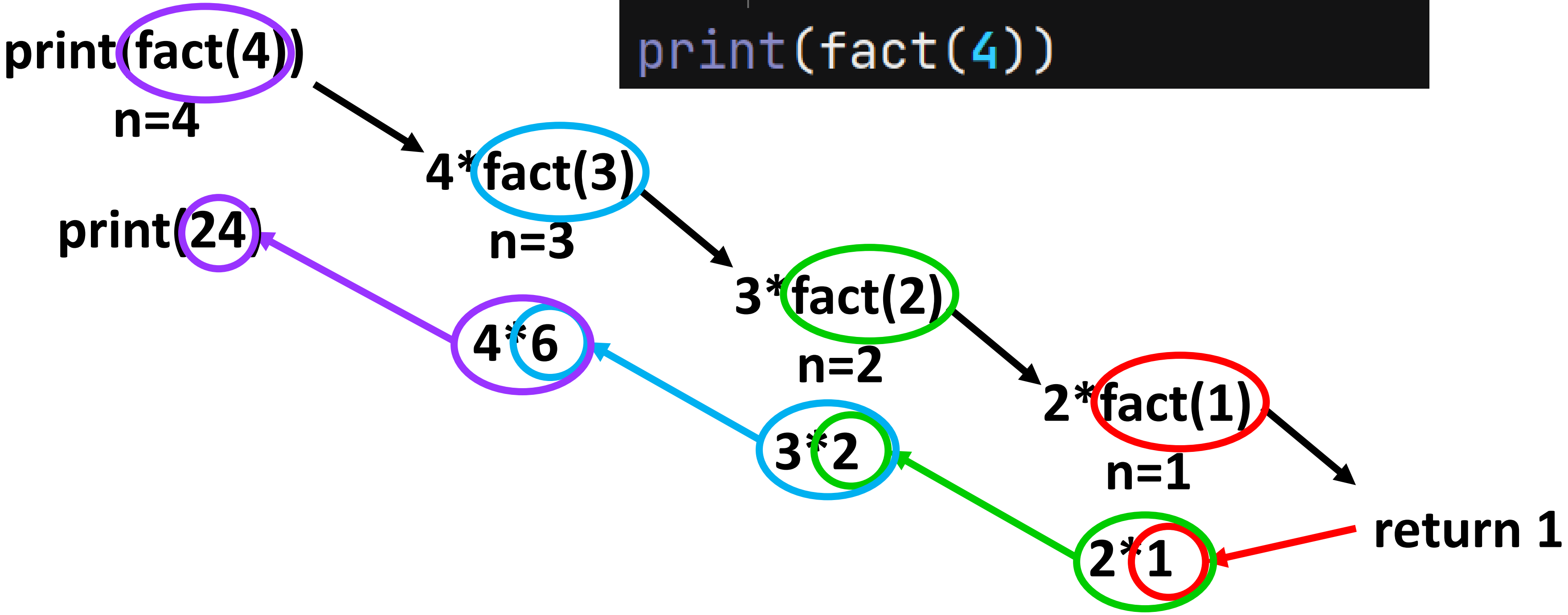
Base case:
Keep reducing until reach a simple case that can be solved directly:

$\boxed{\text{When } b=1,\ a*b = a}$ ← Base case

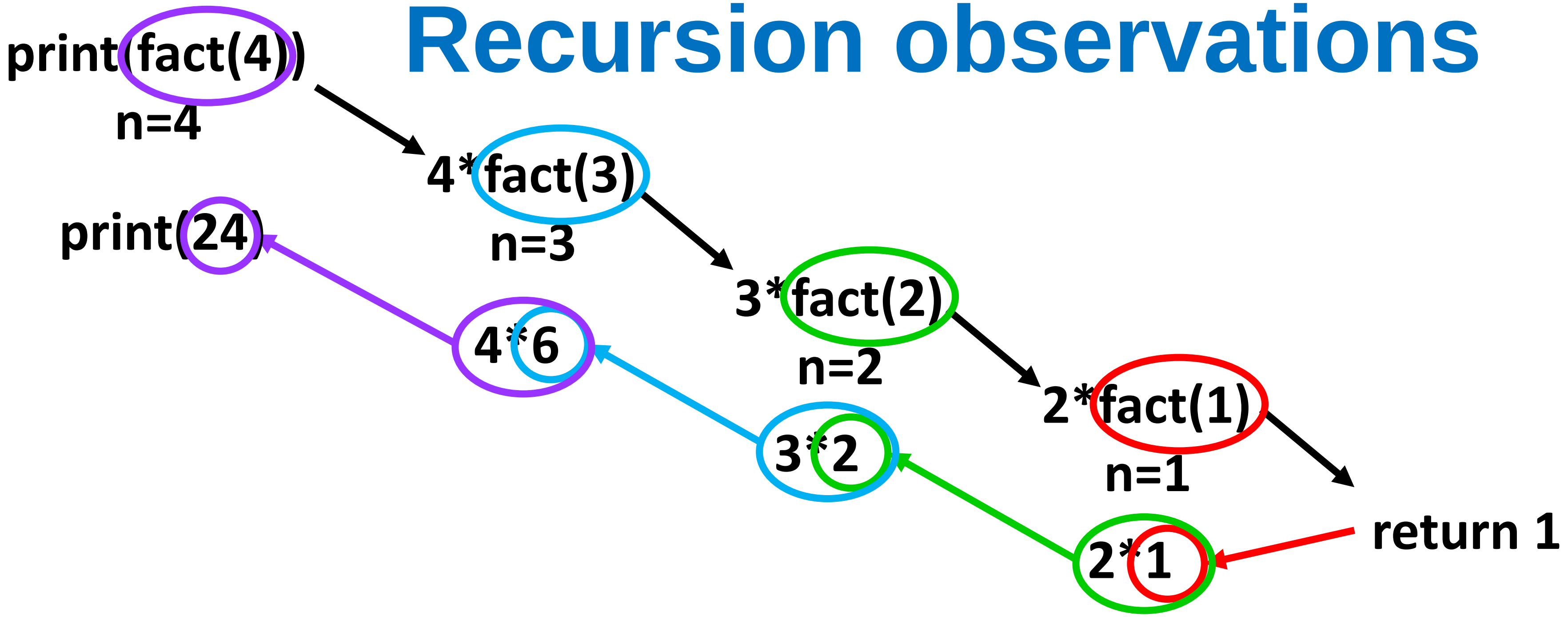
```python
def mult_rec(a,b):
    if b==1:
        return a
    else:
        return a+mult_rec(a,b-1)
print(mult_rec(10,6))
```

Recursion execution demonstration

```python
def fact(n):
    if n==1:
        return 1
    else:
        return n*fact(n-1)
print(fact(4))
```



Recursion observations



- Each recursive step creates its own scope/environment (use same variable names, but in separate scopes)
- Variable binding does not change by recursive call
- Flow control passes back to previous scope when function call returns a value

Recursion vs. loop overview

```python
def fact_it(n):
    res=1
    for i in range(1,n+1):
        res*=i
    return res
print(fact_it(4))
```

```python
def fact(n):
    if n==1:
        return 1
    else:
        return n*fact(n-1)
print(fact(4))
```

Fibonacci Series

Recursion example with two base cases and two recursive calls

```python
def fibonacci(x):
    if x==0 or x==1:
        return x
    else:
        return fibonacci(x-1)+fibonacci(x-2)
```

Palindrome testing
Recursion example with strings

```
def parseS(s):
    return ''.join(s.lower().split(' '))

def isPal(s):
    if len(s)<=1:
        return True
    else:
        return s[0]==s[-1] and isPal(s[1:-1])
print(isPal(parseS("Was it a car or a cat I saw")))
```

Recursion exercise
HW: Implement GCD with recursion

What is the greatest common devisor of two numbers, a and b?

Pseudo code:

$a = q_0 b + r_0$

$b = q_1 r_0 + r_1$

$r_0 = q_2 r_1 + r_2$

$r_1 = q_3 r_2 + r_3$

…

$r_{k-2} = q_k\, r_{k-1} + r_k \leftrightarrow r_k = r_{k-2} \,\%\, r_{k-1}$

Until $r_k = 0$ is reached.

The greatest common devisor is r_{k-1}

For example,

For a = 1071 and b = 462

Step k	Equation	Quotient and remainder
0	$1071 = q_0\, 462 + r_0$	$q_0 = 2$ and $r_0 = 1071\%462 = 147$
1	$462 = q_1\, 147 + r_1$	$q_1 = 3$ and $r_1 = 462\%147 = 21$
2	$147 = q_2\, 21 + r_2$	$q_2 = 7$ and $r_2 = 147\%21 = 0$; algorithm ends