CS 161
Intro to CS I

Recursion

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Recursion

- What is it?
  - Function that calls itself 1 or more times (directly or indirectly)
  - Has 1 or more base case for stopping
  - Inductive reasoning: general case must eventually be reduced to a base case

Example: Drawing Rectangles

- Iterative Solution:

```
void draw_rect(int i) {
    for( ; i > 0; i--){
      cout << "*******“ << endl;
      cout << "*          *“ << endl;
      cout << "*******“ << endl << endl;
    }
}
```

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Example: Drawing Rectangles

- Recursive Solution

```
void draw_rect(int i) {
      if(i>0){      //Base case
        draw_rect(--i);    //Recursive call
        cout << "*******“ << endl;
        cout << "*          *“ << endl;
        cout << "*******“ << endl << endl;
      }
  }
```

What is different when we call after?

- Recursive Solution

```
void draw_rect(int i) {
     if(i>0){      //Base case
       cout << "******“ << endl;
       cout << "*          *“ << endl;
       cout << "******“ << endl << endl;
       draw_rect(--i);    //Recursive call
     }
}
```

Example: Factorial

- Definition

  $0! = 1;$

  $n! = n * (n-1) * \ldots * (n-(n-1)) * 1 = n * (n-1)! \; ; \; n > 0$

Iterative Factorial

factorial(0) = 1;

factorial(n) = n*n-1*n-2*…*n-(n-1)*1;

```
long factorial(int n) {
        long fact;
        if(n==0)
            fact=1;
        else
           for(fact=n; n > 1; n--)
              fact=fact*(n-1);
       return fact;
}
```

Recursive Factorial

factorial(0) = 1;
factorial(n) = n*factorial(n-1);

```
long factorial(int n) {
    if (n == 0)      // Base case
      return 1;
    else
      return n * factorial(n - 1);    // Recursive call
 }
```

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Computing Factorial Iteratively

factorial(4)

factorial(0) = 1;
factorial(n) = n*(n-1)*…*2*1;

Computing Factorial Iteratively

factorial(0) = 1;
factorial(n) = n*(n-1)*…*2*1;

factorial(4) = 4 * 3

Computing Factorial Iteratively

factorial(0) = 1;
factorial(n) = n*(n-1)*…*2*1;

factorial(4) = 4 * 3
= 12 * 2

Computing Factorial Iteratively

factorial(0) = 1;
factorial(n) = n*(n-1)*...*2*1;

factorial(4) = 4 * 3
= 12 * 2
= 24 * 1

Computing Factorial Iteratively

factorial(0) = 1;
factorial(n) = n*(n-1)*...*2*1;

factorial(4) = 4 * 3
= 12 * 2
= 24 * 1
= 24

Computing Factorial Recursively

```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

factorial(4)

Computing Factorial Recursively

factorial(0) = 1;
factorial(n) = n*factorial(n-1);

factorial(4) = 4 * factorial(3)

Computing Factorial Recursively

factorial(0) = 1;
factorial(n) = n*factorial(n-1);

factorial(4) = 4 * factorial(3)
= 4 * (3 * factorial(2))

Computing Factorial Recursively

factorial(0) = 1;
factorial(n) = n*factorial(n-1);

factorial(4) = 4 * factorial(3)
= 4 * (3 * factorial(2))
= 4 * (3 * (2 * factorial(1)))

Computing Factorial Recursively

```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

factorial(4) = 4 * factorial(3)

= 4 * (3 * factorial(2))

= 4 * (3 * (2 * factorial(1)))

= 4 * (3 * (2 * (1 * factorial(0))))

Computing Factorial Recursively

factorial(0) = 1;
factorial(n) = n*factorial(n-1);

factorial(4) = 4 * factorial(3)
= 4 * (3 * factorial(2))
= 4 * (3 * (2 * factorial(1)))
= 4 * (3 * (2 * (1 * factorial(0))))
= 4 * (3 * (2 * (1 *1)))

Computing Factorial Recursively

factorial(0) = 1;
factorial(n) = n*factorial(n-1);

factorial(4) = 4 * factorial(3)
= 4 * (3 * factorial(2))
= 4 * (3 * (2 * factorial(1)))
= 4 * (3 * (2 * (1 * factorial(0))))
= 4 * (3 * (2 * (1 *1)))
= 4 * (3 * (2 * 1))

Computing Factorial Recursively

```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

factorial(4) = 4 * factorial(3)
= 4 * (3 * factorial(2))
= 4 * (3 * (2 * factorial(1)))
= 4 * (3 * (2 * (1 * factorial(0))))
= 4 * (3 * (2 * (1 *1)))
= 4 * (3 * (2 * 1))
= 4 * (3 * 2)

Computing Factorial Recursively

```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

factorial(4) = 4 * factorial(3)
= 4 * (3 * factorial(2))
= 4 * (3 * (2 * factorial(1)))
= 4 * (3 * (2 * (1 * factorial(0))))
= 4 * (3 * (2 * (1 *1)))
= 4 * (3 * (2 * 1))
= 4 * (3 * 2)
= 4 * 6

Computing Factorial Recursively

```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

factorial(4) = 4 * factorial(3)
= 4 * (3 * factorial(2))
= 4 * (3 * (2 * factorial(1)))
= 4 * (3 * (2 * (1 * factorial(0))))
= 4 * (3 * (2 * (1 *1)))
= 4 * (3 * (2 * 1))
= 4 * (3 * 2)
= 4 * 6
= 24

Differences

- Pros
  - Readability
- Cons
  - Efficiency
  - Memory

Recursive Factorial

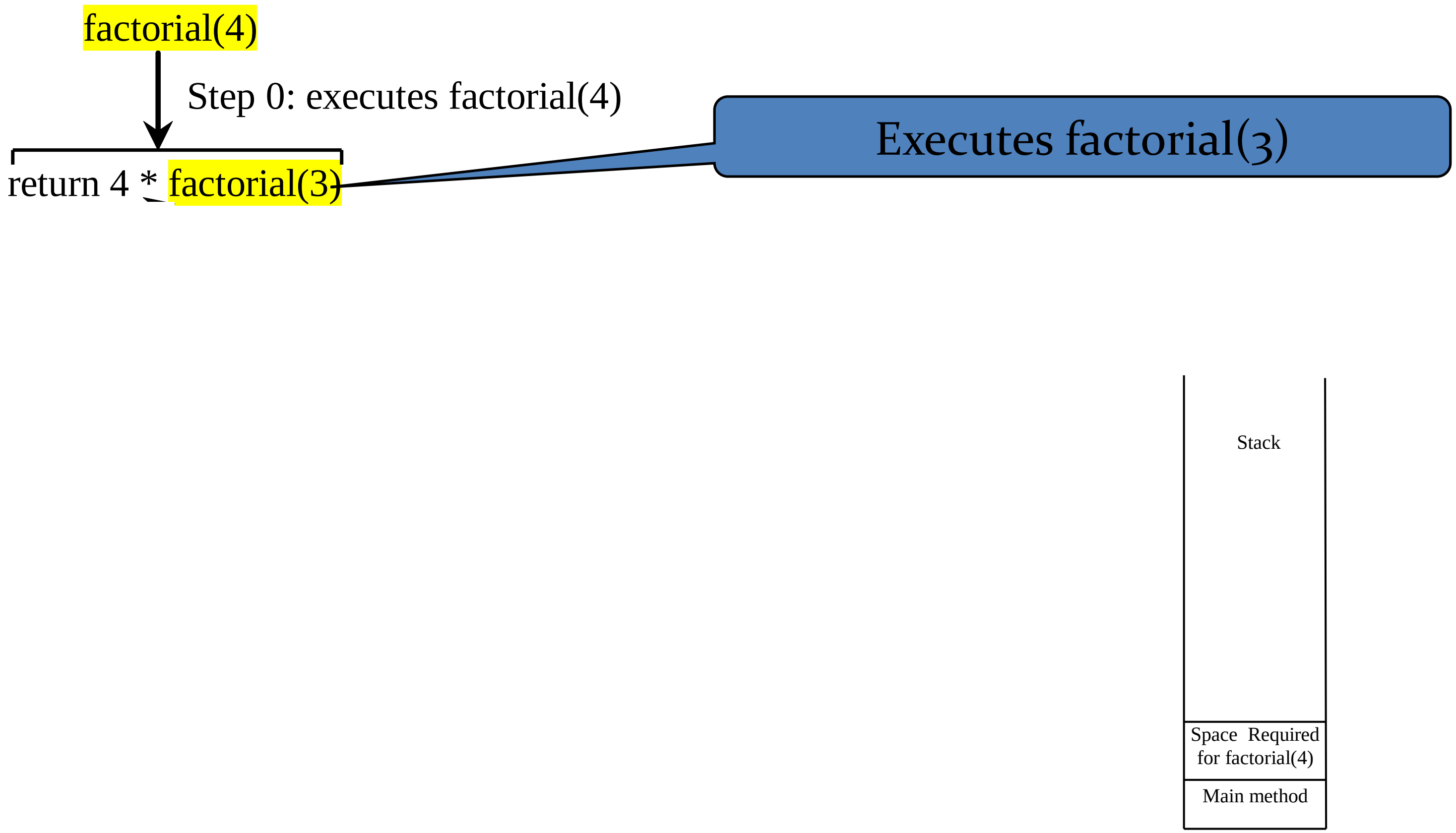
Executes factorial(4)

factorial(4)

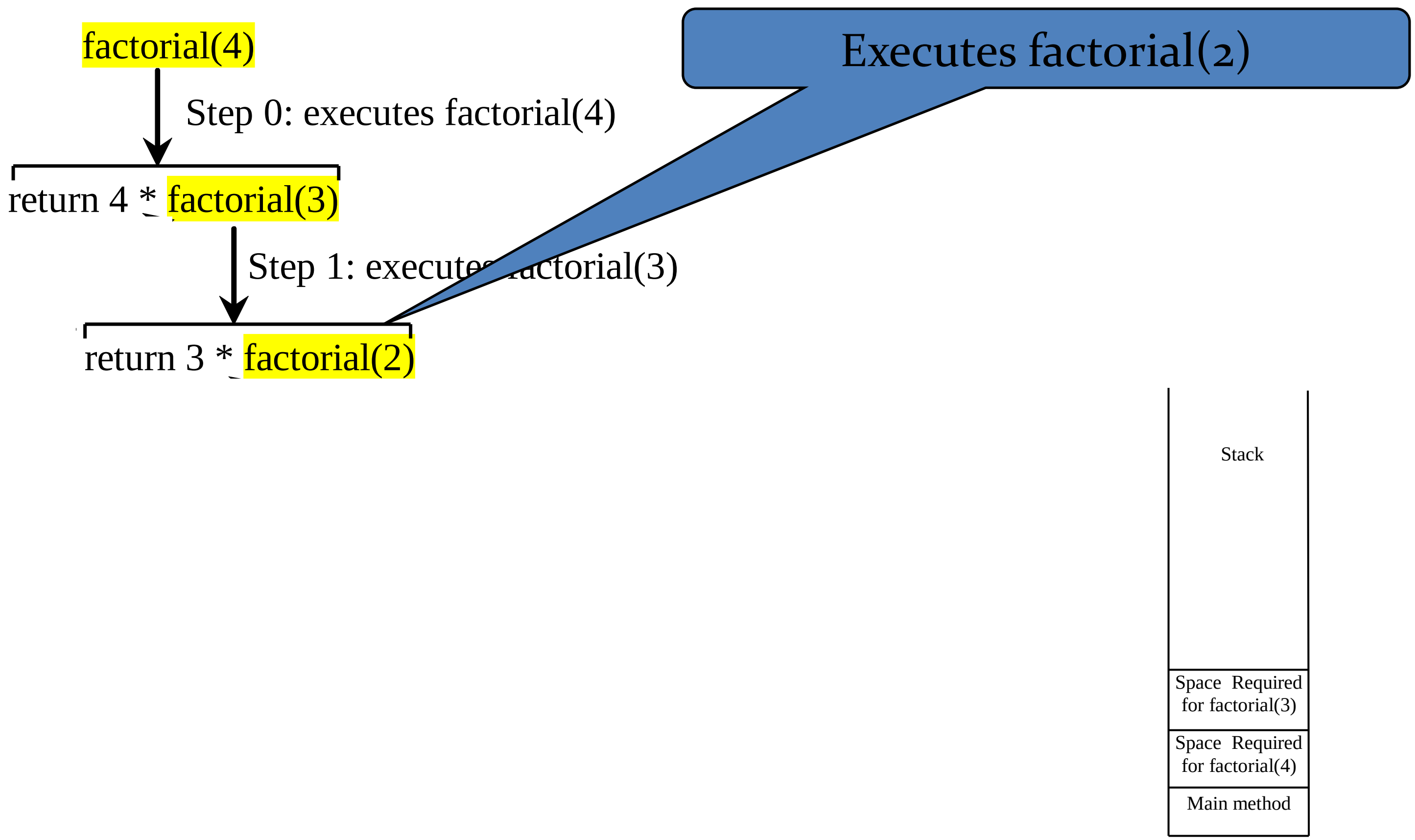
Stack

Main method

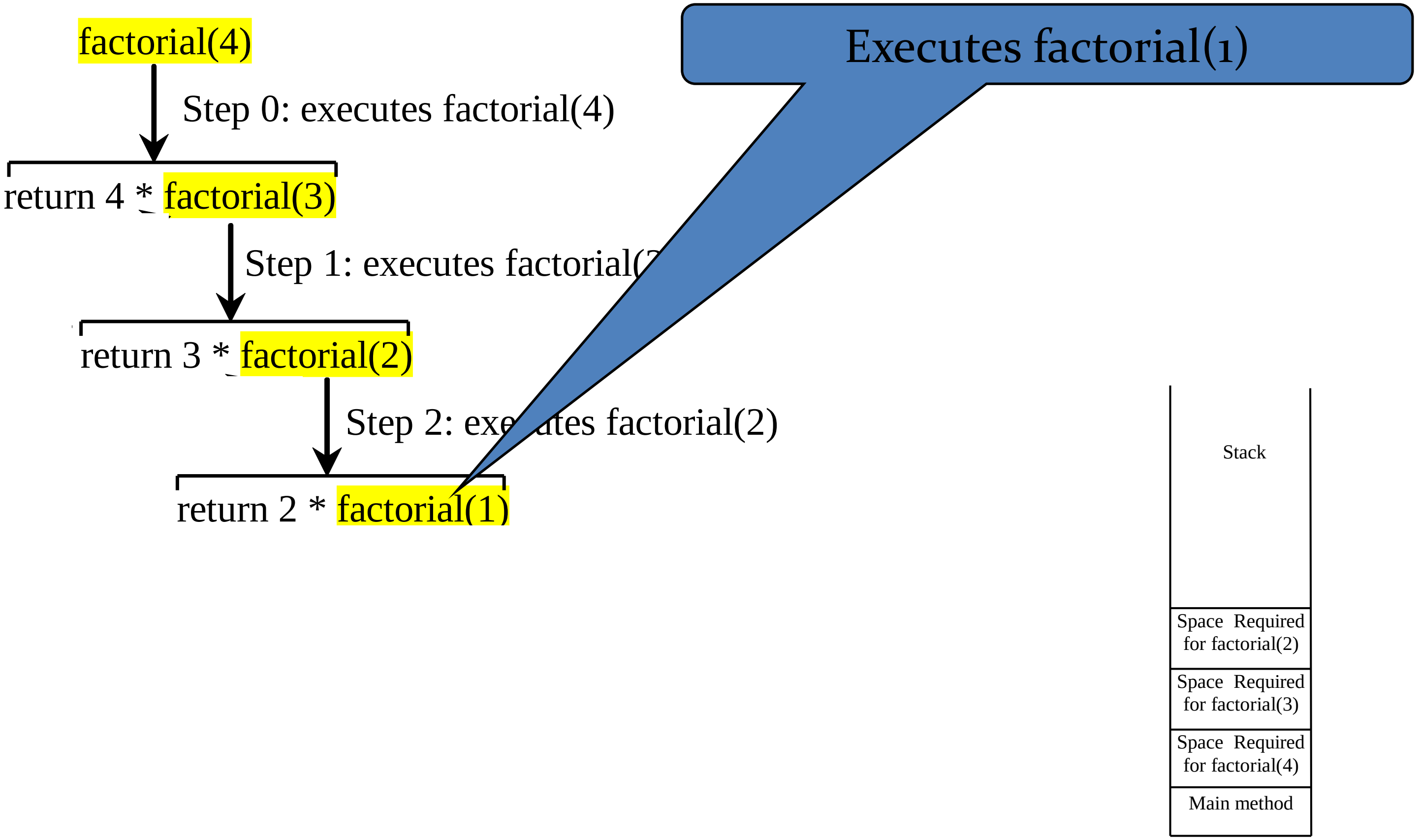
Recursive Factorial



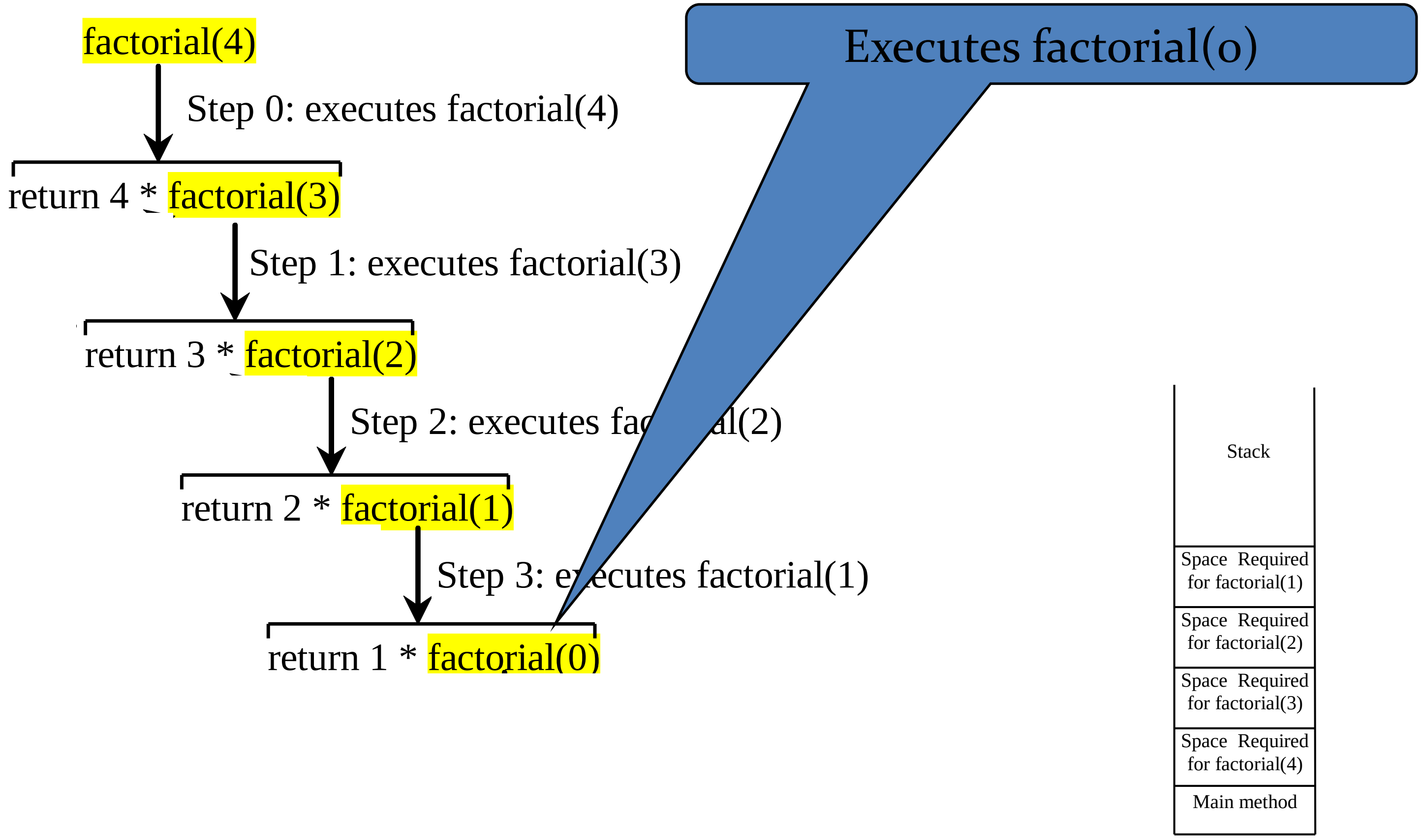
Recursive Factorial



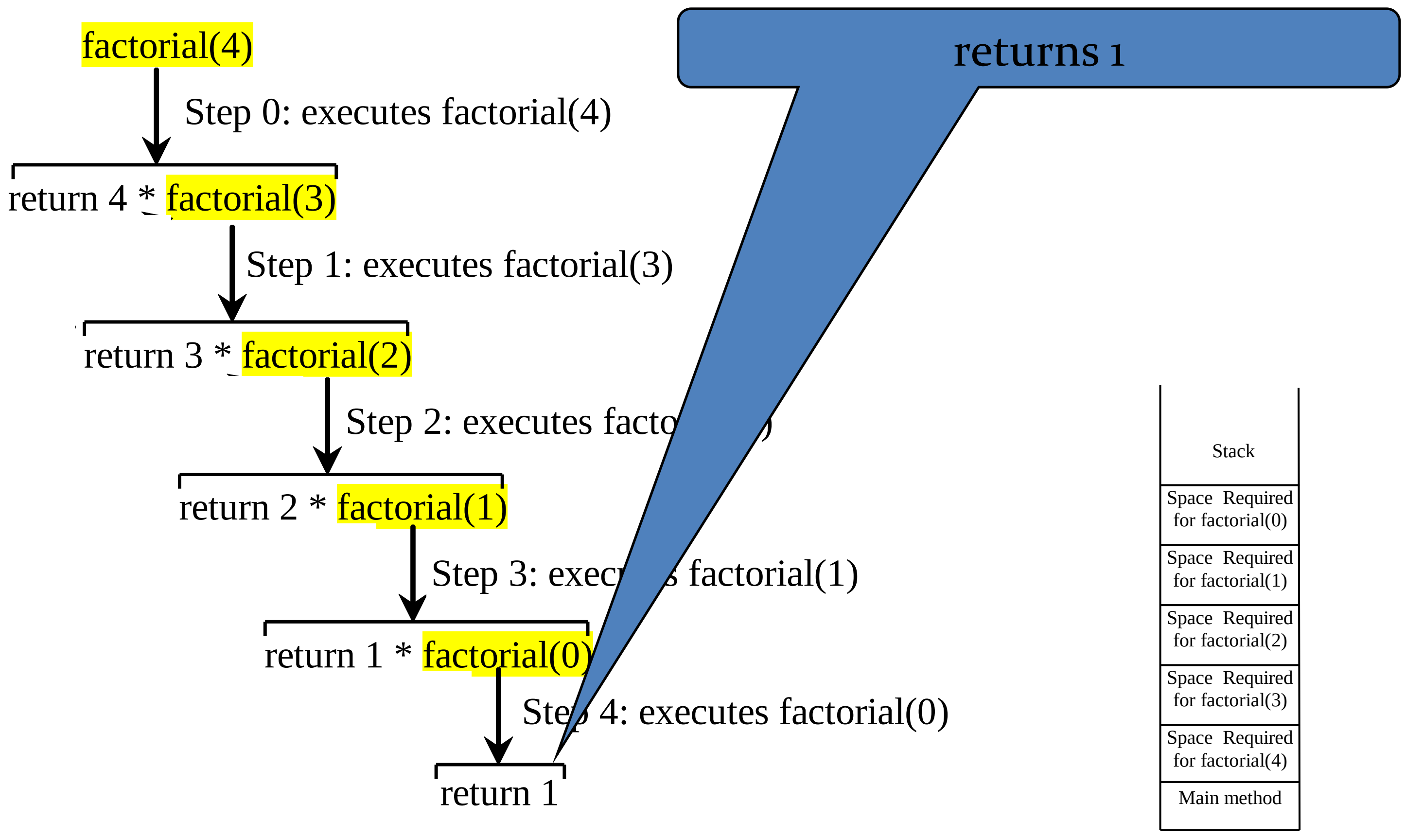
Recursive Factorial



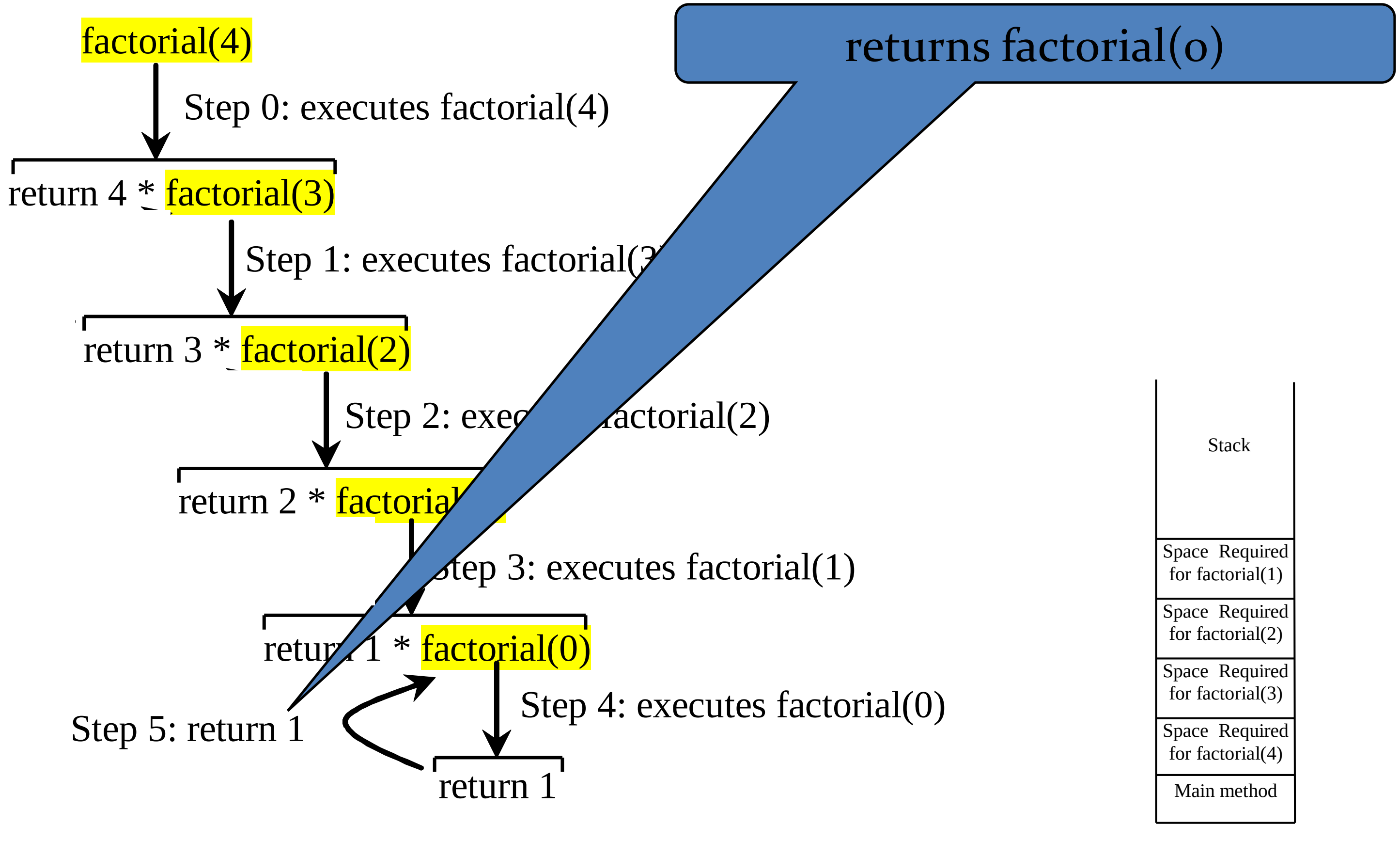
Recursive Factorial



Recursive Factorial



Recursive Factorial



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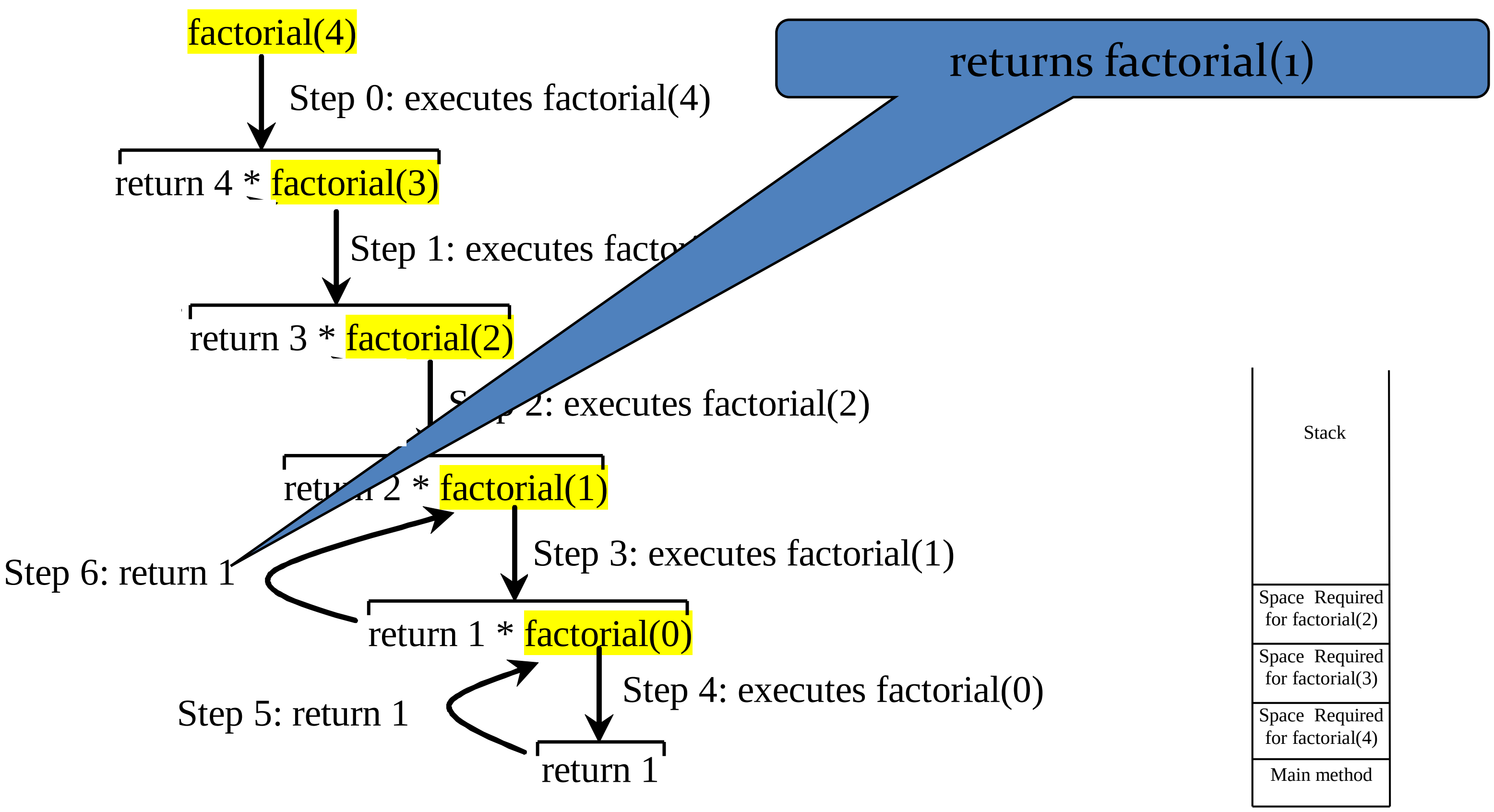
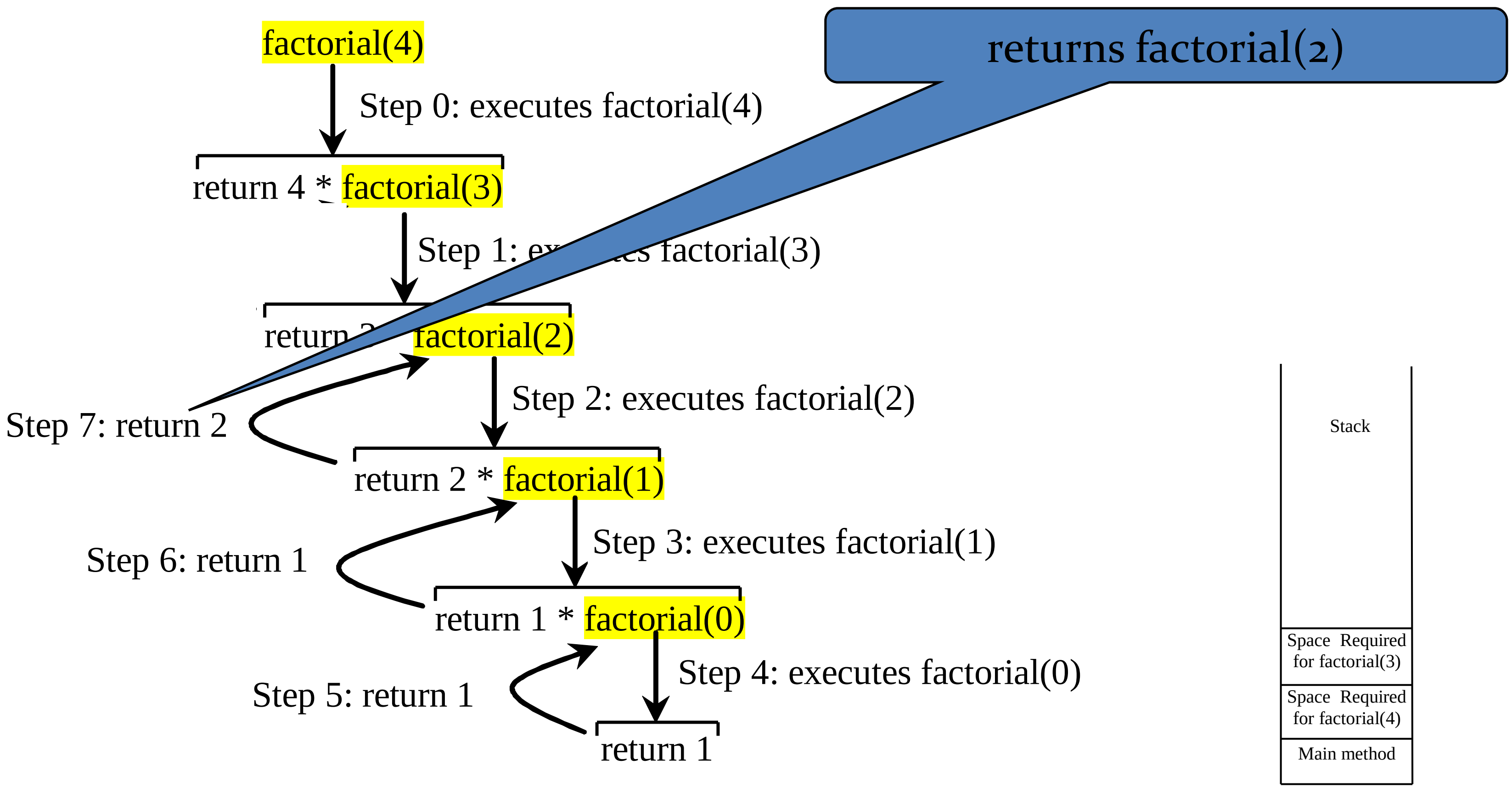
Recursive Factorial



Recursive Factorial



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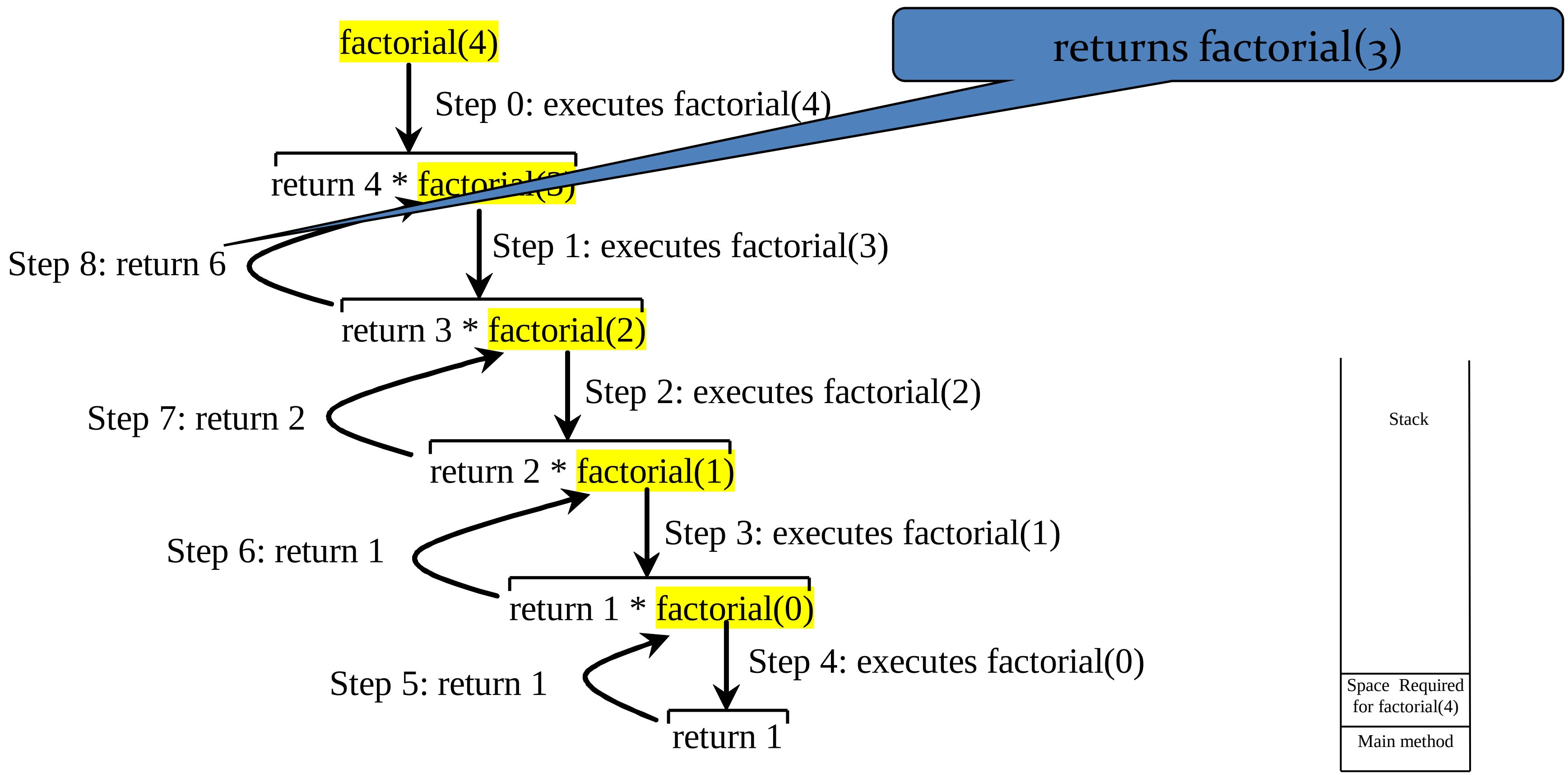
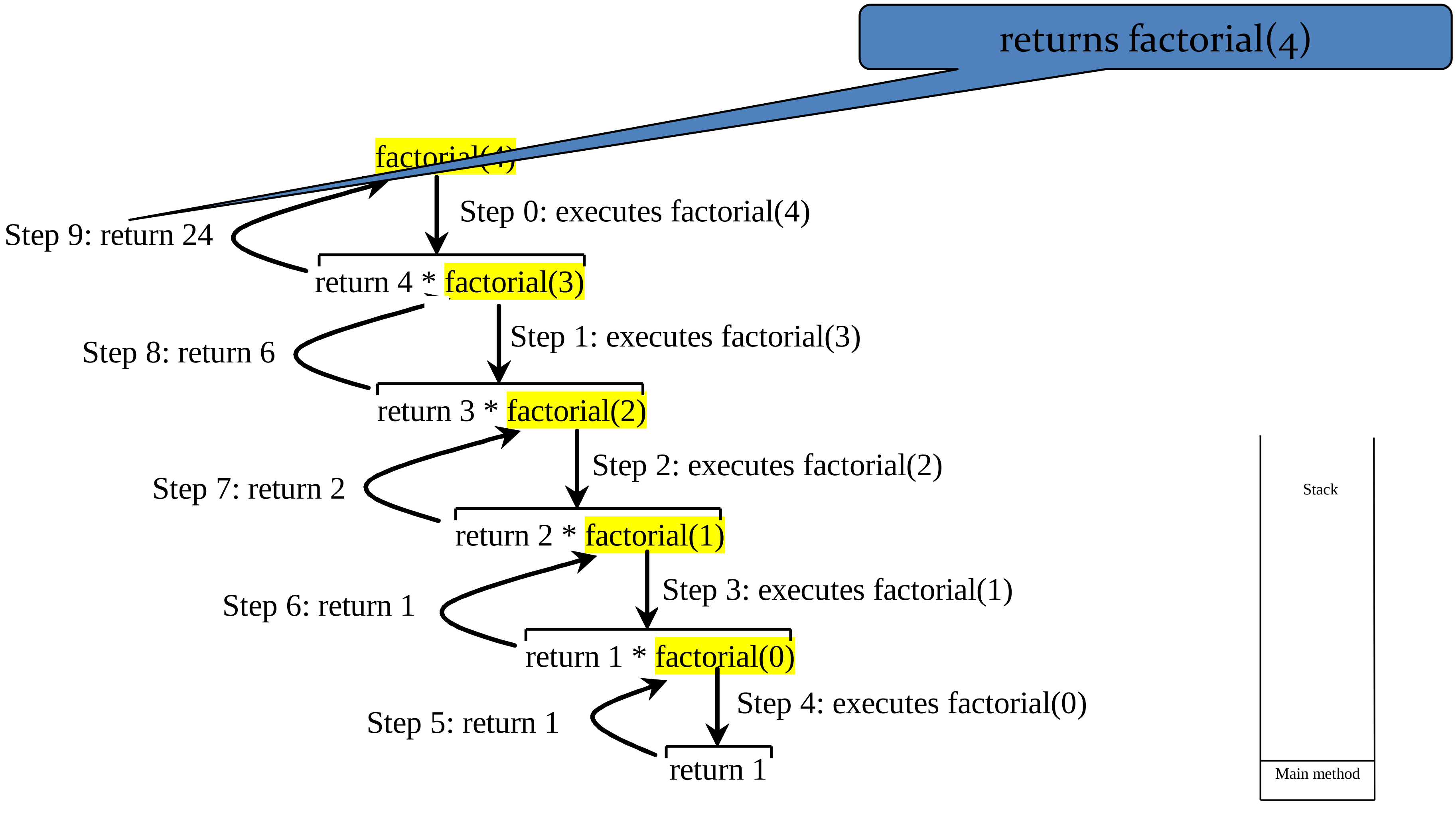
Recursive Factorial



Recursive Factorial



In-class Exercise #4

- Get into groups of 4 – 5.
- Write your own recursive *int pwr()* function that takes two integers as arguments and returns the integer result.
  - What does the function prototype look like?
  - Now, write the function definition…

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