CS 2211
Systems Programming

Recursion

Recursive Definitions

- ***Recursion***:
  defining something *in terms of itself*

- ***Recursive definition***
  - Uses the word or concept being defined ***in the definition itself***

  - Includes a ***base case*** that is defined directly, ***without*** self-reference

Recursive Definitions

- A recursive definition consists of two parts:
  - The ***base case***: this defines the "***simplest***" case or starting point
  - The ***recursive part***: this is the "***general case***", that describes all the other cases in terms of "***smaller***" versions of itself
- Why is a base case needed?
  - A definition without a non-recursive part causes ***infinite recursion***

Recursive Definitions

- Mathematical formulas are often expressed recursively

- ***Example***: the formula for ***factorial***

  *for any positive integer **n**, **n!** (n factorial) is defined to be the product of all integers between **1** and **n** inclusive*

- Express this definition recursively

  1! = 1 (the base case)

  n! = n * (n-1)! for n>=2

- Now determine the value of **4!**

Discussion

- ***Recursion*** is an alternative to ***iteration***, and can be a very powerful problem-solving technique

- What is ***iteration***? repetition, as in a loop

- What is ***recursion***? defining something in terms of a ***smaller*** or ***simpler*** version of itself (why smaller/simpler?)

Recursive Programming

- ***Recursion*** is a programming technique in which a method can ***call itself*** to solve a problem

- A function in C that invokes itself is called a
  recursive method
  and must contain code for

  – The ***base case***
  – The ***recursive part***

Example of Recursive Programming

- Consider the problem of computing the sum of all the numbers between **1** and **n** inclusive

  e.g. if **n** is **5**, the sum is (in an iterative processes)

  1 + 2 + 3 + 4 + 5

- How can this problem be expressed recursively?

  Hint: the above sum is the same as

  5 + 4 + 3 + 2 + 1

Recursion in C

END OF Part 1

```c
#include <stdio.h>

int SumIter(int );

int main()
{
   int i = 3 , x;

   x = SumIter(i);
   printf("\nIteration x: %d\n", x);

   return 0;
}

int SumIter(int ir)
{
    if (ir == 1)
      return (1);
    else
    {
        int totalSum = 0;
        for (int k = 1; k <= ir; k++)
        {
            totalSum = totalSum + k;
        }
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    }
}
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	399	
	…	
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x	404 - 407	
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x	404 - 407	
ir	440 - 443	3
totalSum	444 - 447	0
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ir	440 - 443	3
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    }
}
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Label	Address	Value
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i	400 - 403	3
x	404 - 407	
ir	440 - 443	3
totalSum	444 - 447	6
k	448 - 451	1
	...	
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OUTPUT:
Iteration x: 6

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ir	440 - 443	3
result	444 - 447	
ir	444 - 447	2
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ir	440 - 443	3
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ir	440 - 443	3
result	444 - 447	
ir	444 - 447	2
result	448 - 451	
ir	468 - 471	1
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result	444 - 447	
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ir	468 - 471	1
result	472 - 475	
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2 + 1

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3

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3 + 3

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6

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```c
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int SumRec(int );

int main()
{
   int i = 3 , x;

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   return 0;
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    }
    else
    {
        result = (ir + SumRec(ir - 1));
    }
    return (result);
}
```

6

Label	Address	Value
	399	
i	400 - 403	3
x	404 - 407	
	...	
	...	
	...	
	...	
	...	
	...	
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	...	
	...	

OUTPUT:
Factorial x: 6

Recursion in C

END OF Part 2

How Recursion Works

- What happens when ***any*** **function** is called?
  - A ***call frame*** is set up
  - That call frame is pushed onto the ***runtime stack***

- What happens when a recursive method "***calls itself***"? It's actually just like calling any other method!
  - A ***call frame*** is set up
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How Recursion

- What happens when ***any*** **funct**
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siv
ny

onto the ***runtime stack***

How Recursion

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  - A ***call frame*** is set up
  - That call frame is pushed on

Label	Address	Value
	399	
i	400 - 403	3
x	404 - 407	
ir	440 - 443	3
result	444 - 447	
	...	
	...	
	...	
	...	
	...	
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	...	
	...	
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Label	Address	Value
	399	
i	400 - 403	3
x	404 - 407	
ir	440 - 443	3
result	444 - 447	
ir	444 - 447	2
result	448 - 451	
	...	
	...	
	...	
	...	
	...	
	...	
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	...	

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result	448 - 451	
ir	468 - 471	1
result	472 - 475	1
	...	
	...	
	...	
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- What happens when a recursiv
  It's actually just like calling any
  - A ***call frame*** is set up
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How Recursion Works

- Note: For a recursive **function** , how many copies of the code are there?
  - Just one! (like any other **function**)

- When does the recursive function stop calling itself?
  - When the base case is reached

- What happens then?
  - ***That invocation*** of the function completes,
    its call frame is popped off the runtime stack,
    and
    control returns to ***the function that invoked it***

How Recursion Works

- But which function invoked it?
  the ***previous invocation*** of the recursive function
  - This function now completes,
    its call frame is popped off the runtime stack,
    and
    control returns to ***the function that invoked it***

- And so on until we get back to the first invocation of the recursive function

How Recursion W

- But which function invoked it?
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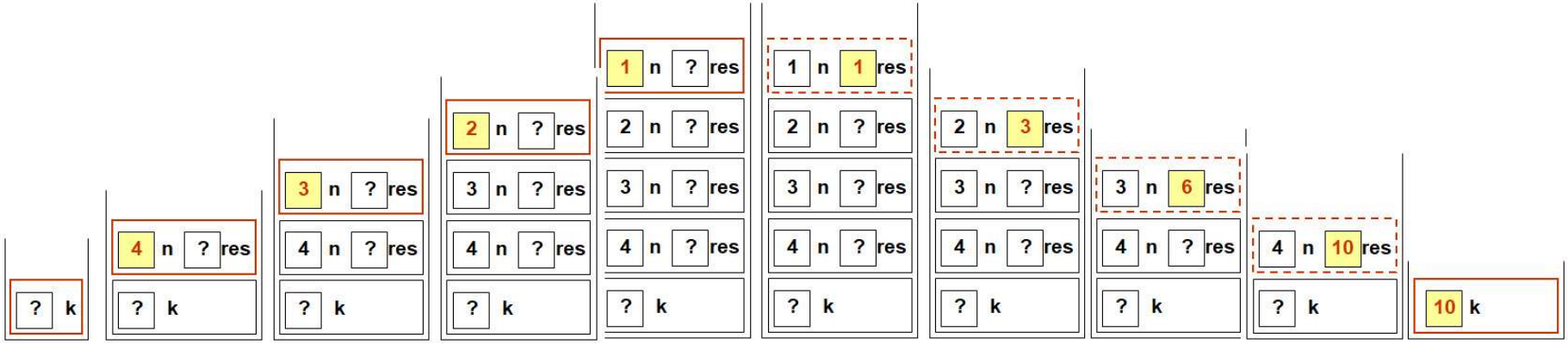

Recursion in C

END OF Recursion