CS19001: Programming and Data Structures Laboratory

Soumyajit Dey, Aritra Hazra;
CSE, IIT Kharagpur

http://cse.iitkgp.ac.in/~aritrah/course/lab/PDS/Autumn2018/CS19101_PDS-Lab_Autumn2018.html

10-Sep-2018

Table of Contents

A mathematical function

$$
\begin{aligned}
&= 0 && \text{if } n = 0,\\
f(n) &= 2n - 1 && \text{if } n > 0,\\
&= -2n && \text{if } n < 0
\end{aligned}
$$

- It would be nice to compute f such that

```
int main ()
{
   int n;
   while (1) {
   printf("Input n : "); scanf("%d",&n);
   printf("f(%d)=%d\n", n, f(n));
   }
}
```

And that is possible

```
int f ( int n )
{
   if (n == 0) return (0);
   else if (n > 0) return (2*n-1);
   else return (-2*n);
}
int main ()
{
   int n;
   while (1) {
   printf("Input n : "); scanf("%d",&n);
   printf("f(%d)=%d\n", n, f(n));
   }
}
```

Function Definition

```
return_type function_name (argument_list)
{
   function body
}
```

- Example

```
int gcd ( int a , int b )
{ int c;
   /* body */
   return c;
}
int main()
{ int x, y, z;
   /* body */
   z=gcd(x,y);
}
```

A more elaborate usage

```
int gcd ( int a , int b )
{
   int r;
   /* body */
   return r;
}
int main ()
{
   int i, j, s = 0;
   for (i=1; i<=20; ++i) {
      for (j=i; j<=20; ++j) {
         s += gcd(j,i);
      }
   }
   printf("The desired sum = %d\n", s);
}
```

Passing arguments by value

```
int gcd ( int a , int b )
{
   /*when called, a=j, b=i*/
   int r,...;
   /*any local assignment on a, b does not
   change i,j in main */

   ...../* body */
   return r;
}
int main ()
{
   ............
   s += gcd(j,i);
   ............
}
```

Passing arguments by value

```
int gcd ( int a , int b )
{
   int r,...; /* local variables like a,b*/
   /* r is not defined outside gcd() */

   ...../* body */
return r;
}
int main ()
{
   int r = 5; /* a different 'r' */
   ............
   s += gcd(j,i);
   ............
}
```

Passing arguments by value

```
int gcd ( int a , int b ) /*a=10,b=6*/
{
   int r,...;

   ......./* body */
return r; /*r=2*/
}
int main ()
{
   int r = 5;
   ............/*j=10,i=6,r= 5*/
   ...r=r+j..../*j=10,i=6,r=15*/
   s += gcd(j,i); /*s+=2*/
   ............/*j=10,i=6,r=15*/
}
```

Passing an array

When you pass an array, the computation effects the array passed by main

```
void bubble(int A[], int n)
{ /*no return type*/
   int c,d,temp;
   for (c=n-2; c>=0; --c){
      for (d=0; d<=c; ++d){
         if (A[d] > A[d+1]){
            temp = A[d];
            A[d] = A[d+1];
            A[d+1] = temp;
         }
      }
   }
}
```

We shall explain the reason later

CS19001: Programming and Data Structures Laboratory

Soumyajit Dey, Aritra Hazra; CSE, IIT Kharagpur

Passing an array

```
int main()
{
   int array[100], n, k;
   printf("Enter no. of elements\n");
   scanf("%d", &n);
   printf("Enter %d integers\n", n);
   for (k = 0; k < n; k++)
      scanf("%d", &array[k]);
   bubble(array, n); /*array is passed*/
   printf("Sorted list\n");
   for ( k = 0 ; k < n ; k++ )
      printf("%d,", array[k]);
   printf("\n");
   return 0; /*sorting reflected on array[]*/
}
```

Table of Contents

The well known Fibonacci function

$$
\begin{aligned}
&= 0 && \text{if } n = 0,\\
f(n) &= 1 && \text{if } n = 1,\\
&= f(n-1) + f(n-2) && \text{if } n \geq 2
\end{aligned}
$$

- Similarly, many other well known functions can be defined *recursively*, i.e., in terms of itself

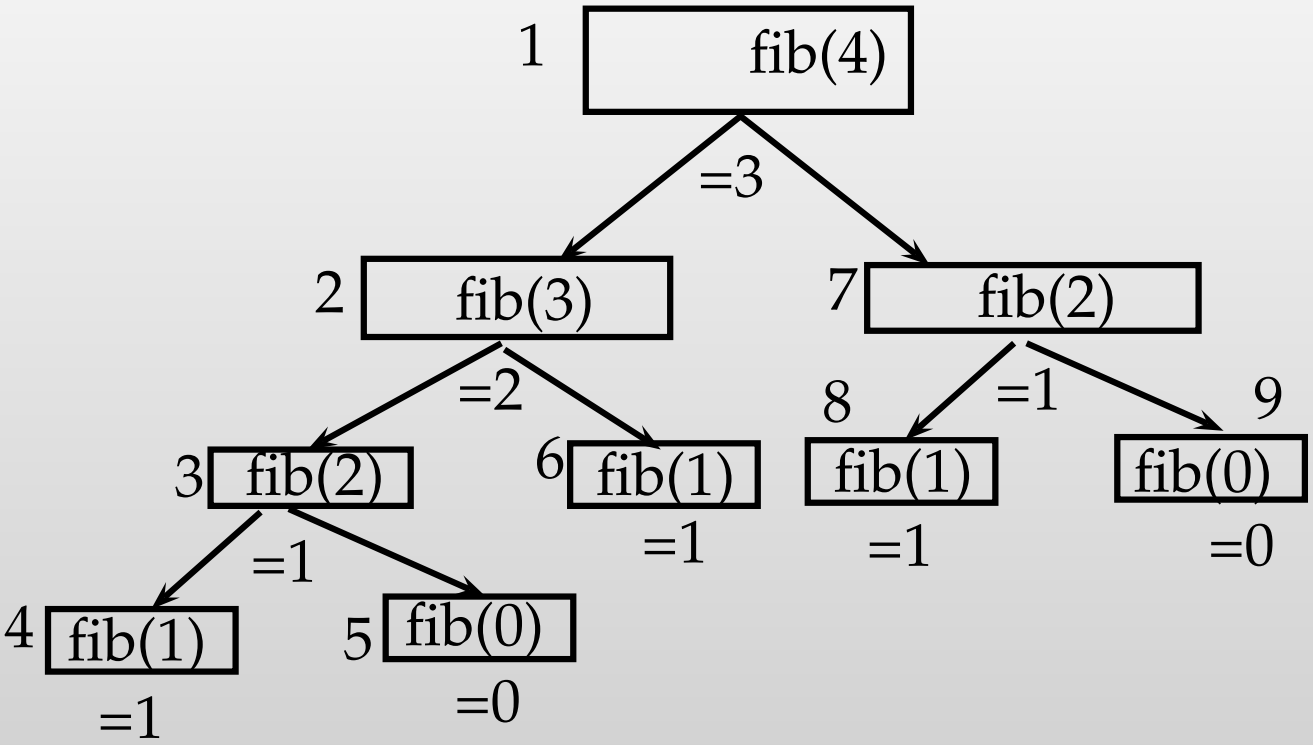
```
int fib ( int n )
 {
    if (n == 0) return (0);
    if (n == 1) return (1);
    return (fib(n-1)+fib(n-2));
 }
```

Why does this work

```
int fib ( int n )
 {
    if (n == 0) return (0);
    if (n == 1) return (1);
    return (fib(n-1)+fib(n-2));
 }
```

- Each call instance of fib works with its own copy of n
- The computer "remembers" every previous state of the problem. This information is "held" by the computer on the "activation stack" (i.e., inside of each function's workspace).

The recursive function call sequence

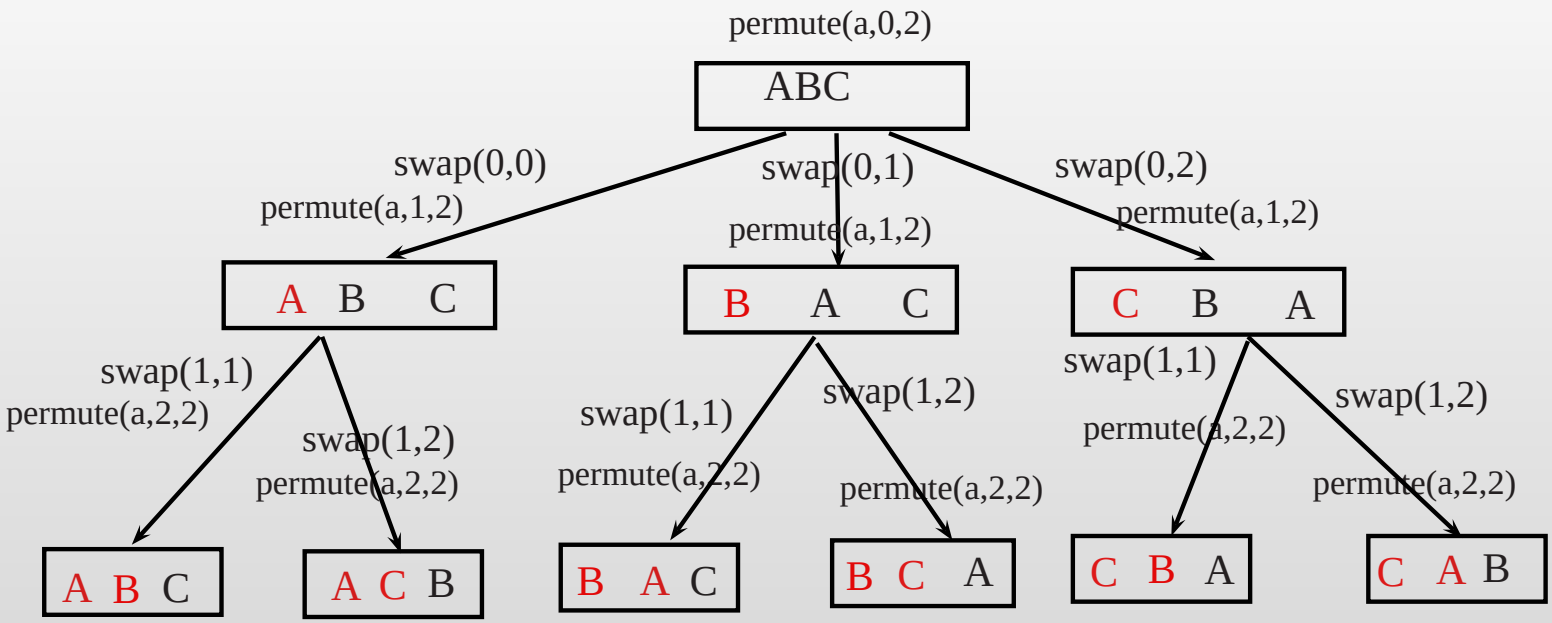


- The call sequence: 1,2,3,..
- The return sequence: 4,5,3,6,2,8,9,7,1

Recursive function for printing all permutations of a given string

```
void permute(char a[], int i, int n)
{//i=current start index
   int j;
   if (i == n) printf("%s\n", a);
   else{
        for (j = i; j <= n; j++){
          swap(a[i], a[j]);
          permute(a, i+1, n);
          swap(a[i], a[j]); //backtrack
        }
    }
}
```

The recursive function call sequence



- Before each function call, position of a letter is fixed (marked in red) after swapping
- After any call returns, swapping is again performed to restore state
- Printing is done at leaf level

Table of Contents

Programming Assignments

Complete and submit during lab

Assignment 1: [Binomial-Sum]

Recall the binomial theorem:

$$(x+y)^n = {}^nC_0 x^n y^0 + \cdots + {}^nC_i x^{n-i} y^i + \cdots + {}^nC_n x^0 y^n$$

Write a C program which takes as input two reals (floats) x and y, a non-negative integer n and returns the value of $(x+y)^n$ as double. Your program should contain the following functions.

- **long int factorial(int);**
- **double power(float, int);**
- **long int find_ncr(int, int);**
- **double find_binomial_sum(float, float, int);**

You are NOT ALLOWED to use **math.h** library.

Do not use a large value of n (> 10 say) for testing purposes. Otherwise, the factorial computation may overflow.

CS19001: Programming and Data Structures Laboratory

Soumyajit Dey, Aritra Hazra; CSE, IIT Kharagpur

Assignment 2: [Derive-Poly]

Main C-Program

- From `main()`, request user to provide the size of array (say n) and all the n array elements (real-valued), $a_0, a_1, a_2, \ldots, a_{n-1}$. This will symbolically represent a polynomial as follows, $f(x) = a_0 + a_1x + a_2x^2 + \cdots + a_ix^i + \cdots + a_{n-1}x^{n-1}$.
- Then ask user to input the order of the derivative (i.e. k^{th}). Please note that, $n \geq k$.
- Print the array elements and the original polynomial, $f(x)$.
- Call `derive()` with suitable parameters (mentioned below).
- Print new polynomial $f^k(x)$ after performing k^{th} derivative over $f(x)$.

Recursive Function:

```
void derive(double a[ ], int n, int k);
```

- Write a **recursive function** `derive()` which takes as argument an array of real numbers, the array size n, and the order of the derivative k.
- When the function returns, the array should contain elements representing the k-th derivative, $f^k(x)$, of the original polynomial, $f(x)$. The new polynomial will be symbolically represented as follows, $f^k(x) = a'_0 + a'_1x + a'_2x^2 + \cdots + a'_ix^i + \cdots + a'_{n-1-k}x^{n-1-k}$.

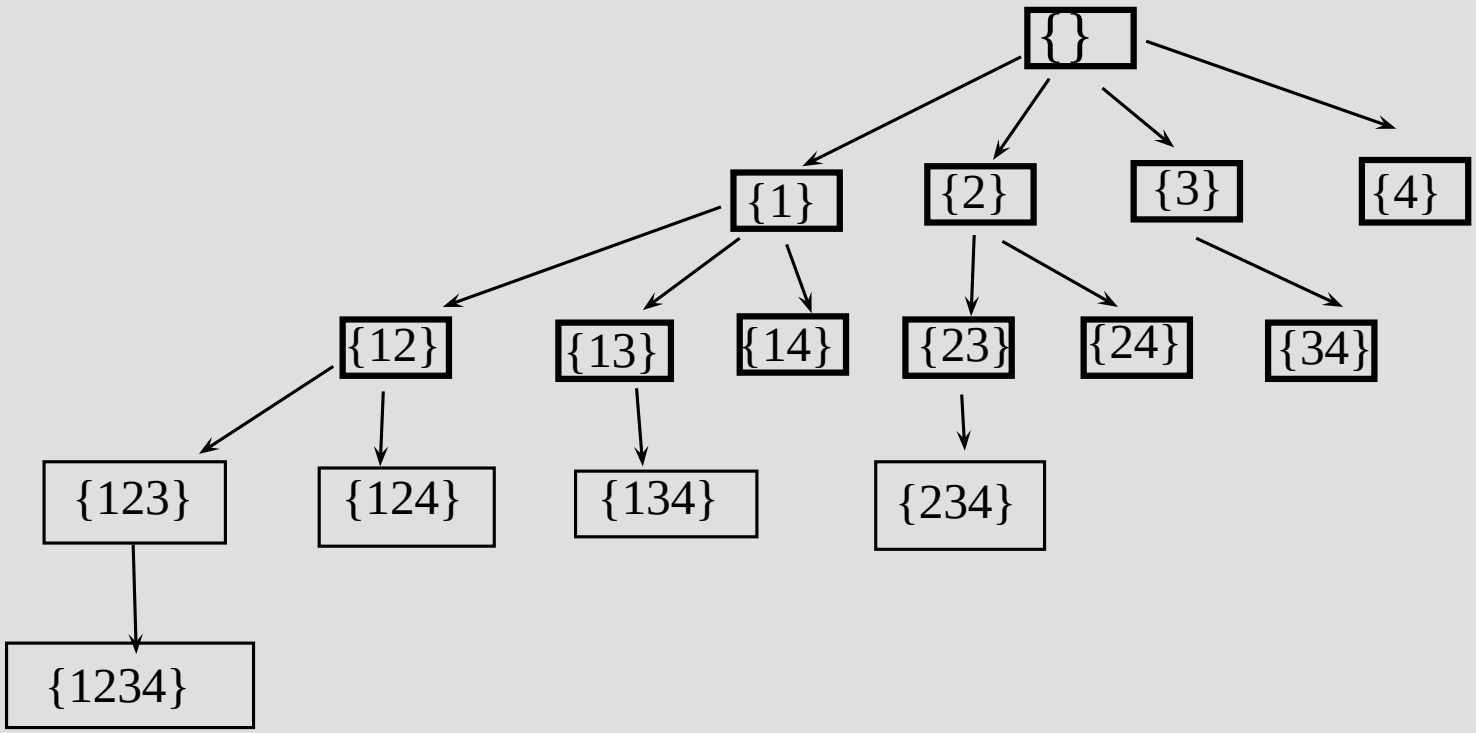
Assignment 3: [Power-Set]

Write a recursive function which takes as argument an integer n and prints all possible subsets of the set $\{1, 2, 3, \cdots, n\}$.

- For both the assignments, write suitable main() functions which shall call the respective functions.
- To help you in designing the recursion, the recursion tree is provided next.

Assignment 3: [Power-Set]

recursion tree, n=4



Thank You