Recursion

Review

- role of functions
- scoping rules
- storage classes
  - auto enforces the scoping rule

Recursion

- A function calls itself.
- A recursive function can be converted to an iterative one

```
int fact(int n)
/* recursive version */
{
  if (n <= 1)
    return 1;
  else
    return (n * fact(n-1));
}
```

```
int fact(int n)
/* iterative version */
{
  int  product = 1;
  for ( ; n > 1; --n)
          product *=n;
  return product;
}
```

Recursion

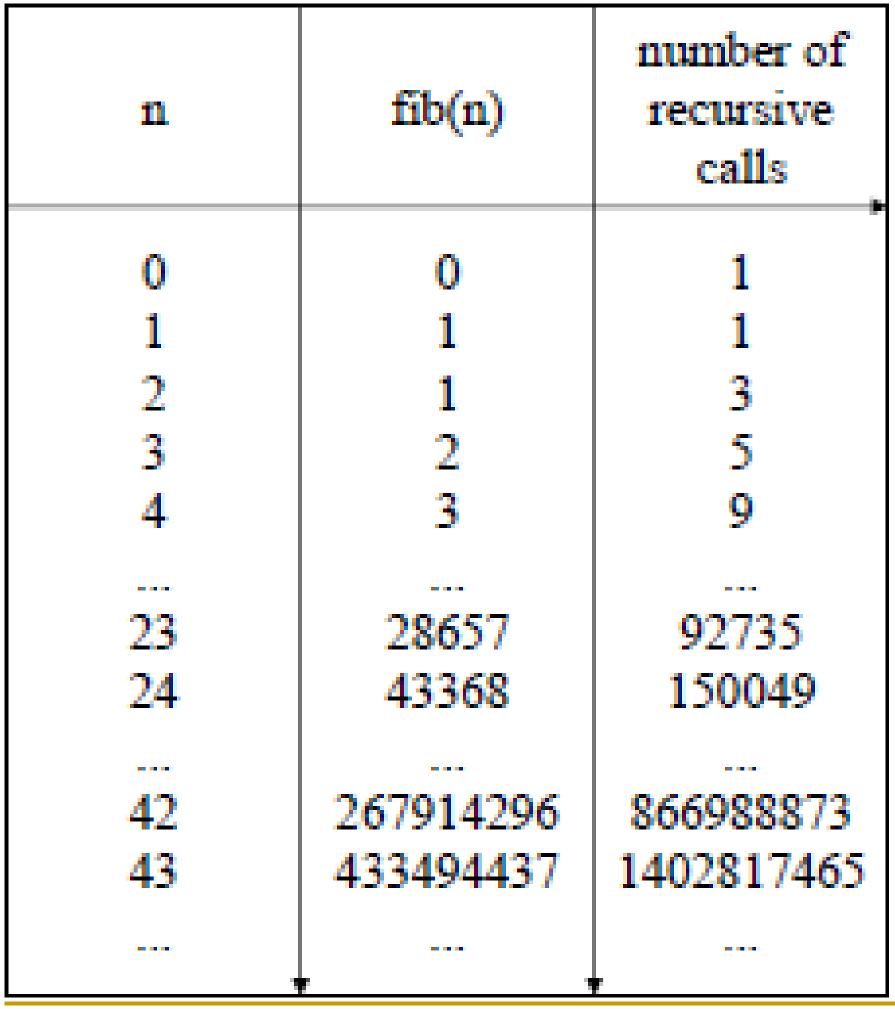
Recursion is said to be more elegant and requires fewer variables, but function calls are costly in time and space.

Recursion

- Fibonacci numbers
  - $f_{i+1} = f_i + f_{i-1}$

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

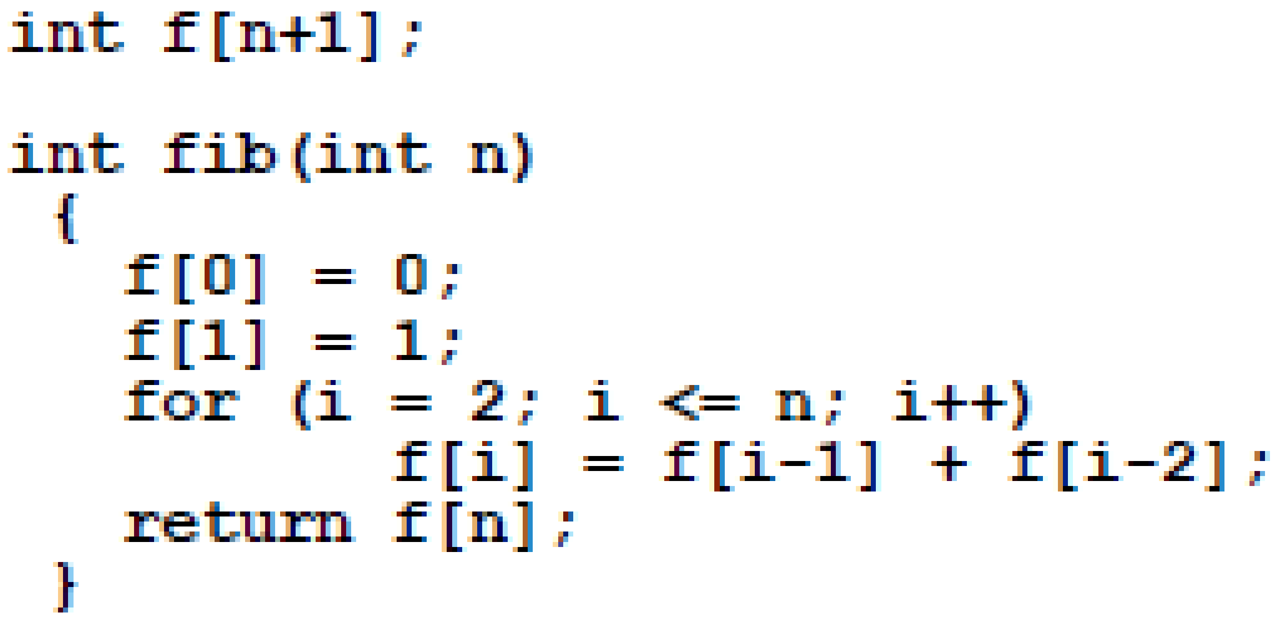
- Exponential increase in function calls



n	fib(n)	number of recursive calls
0	0	1
1	1	1
2	1	3
3	2	5
4	3	9
...	...	...
23	28657	92735
24	43368	150049
...	...	...
42	267914296	866988873
43	433494437	1402817465
...	...	...

Recursion

- iterative version



```
int f[n+1];

int fib(int n)
 {
   f[0] = 0;
   f[1] = 1;
   for (i = 2; i <= n; i++)
          f[i] = f[i-1] + f[i-2];
   return f[n];
 }
```

write backward

```
/* Write a line backwards. */

#include <stdio.h>

void  wrt_it(void);

int main(void)
{

    printf("Input a line:  ");
    wrt_it();
    printf("₩n₩n");
    return 0;
}
```

```
void wrt_it(void)
{
    int   c;

    if ((c = getchar()) != '₩n')
        wrt_it();
    putchar(c);
}
```

Arrays, Pointers, and Strings

One Dimensional Array

- An array is a set of subscripted variables of the same type
- In C, arrays and pointers are interrelated
  - array name is a pointer
- pointer parameters can implement "call-by-reference"
- arrays can be initialized

```
        int a[100] = {0};
```

- external or static arrays are initialized to zero by default
- array declaration without size

```
  int a[] = {2, 3, 4, 7};
  char s[] = "abc";
```

Pointers

- address
- pointers take addresses as values
  - NULL == 0 == FALSE
- Usage

```
p = & a;
b = *p;
v == *&v  (for any variable v)
p == &*p  (if p is a pointer)
```

call-by-reference

```
#include <stdio.h>

void   swap(int *, int *);

int main(void)
{
   int    i = 3, j = 5;

   swap(&i, &j);
   printf("%d  %d\n", i, j);
     /* 5  3 is printed */
   return 0;
}
```

```
void swap(int *p, int *q)
{
   int   tmp;

   tmp = *p;
   *p = *q;
   *q = tmp;
}
```

swap

Example: swapping values of variables in a calling environment by using pointers called-by-value to achieve call-by-reference effect

Arrays and Pointers

- If the variable p is a pointer to a type(say, integer) then p+1 yields the address for the next variable of that type

```
int i;           /* 4 bytes integer */
 int  a[ ];      /* array or  pointer */
```

- a[i] == *(a+i)
- (a + i) == &a[i]