CPE100
Computer Programming for Engineers

MODULE 7
C Recursion

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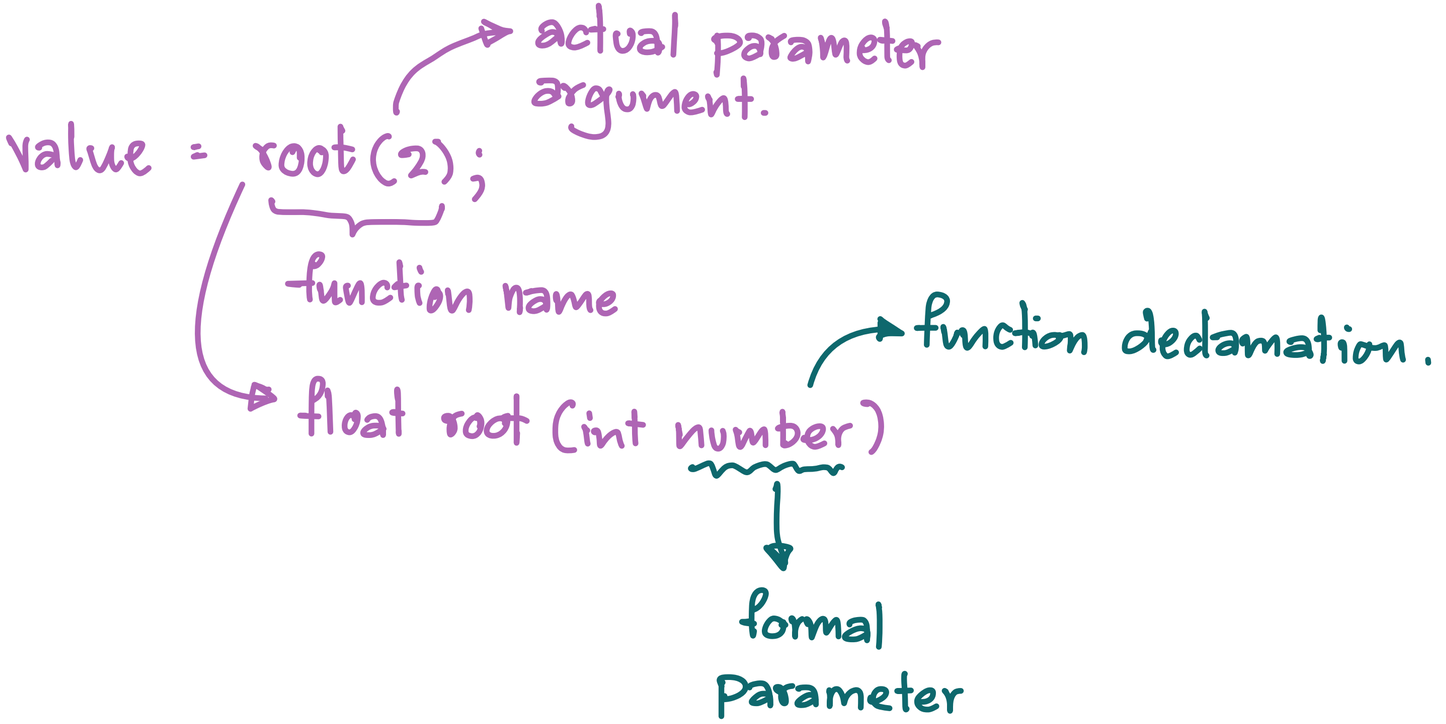
Outlines

Math Induction.

- Recursion = Recursive Function
- Factorial
- Fibonacci



Recursion

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

- A recursive function is a function that calls itself either directly or indirectly.

$5^5 = 3125$ 5^n

Callee

Caller

```
1  // Recursion
2  #include <stdio.h>
3
4  int recursion(int n) {
5      if (n == 1) return 5;
6      else return 5 * recursion( n - 1 );
7  }
8
9  int main()
10 {
11     int i, n = 5;
12     i = recursion(n)
13     return 0;
14 }
15
```

Function Declaration

Base Case

Recursive Case

Function Call

Math Induction. factorial(5) = 5!

Factorial

Basis step = 1! = 1. (0! = 1!)

Induction Step : n! = n*(n-1)!

(n+1)! = (n+1)n!

finite value.

- The factorial of a nonnegative integer n, written n! (pronounced "n factorial"), is the product
- $$n \cdot (n-1) \cdot (n-2) \cdot \ldots \cdot 1$$
- with 1! equal to 1, and 0! defined to be 1.
- Example, 5! is the product 5 * 4 * 3 * 2 * 1, which is equal to 120.
- The factorial of an integer, number, greater than or equal to 0 can be calculated iteratively (nonrecursively) using a for statement as follows:

```
factorial = 1;

for ( counter = number; counter >= 1; --counter )
    factorial *= counter;
```

Factorial

★ A recursive definition of the factorial function is arrived at by observing the following relationship:

$$n! = n \times (n - 1)!$$

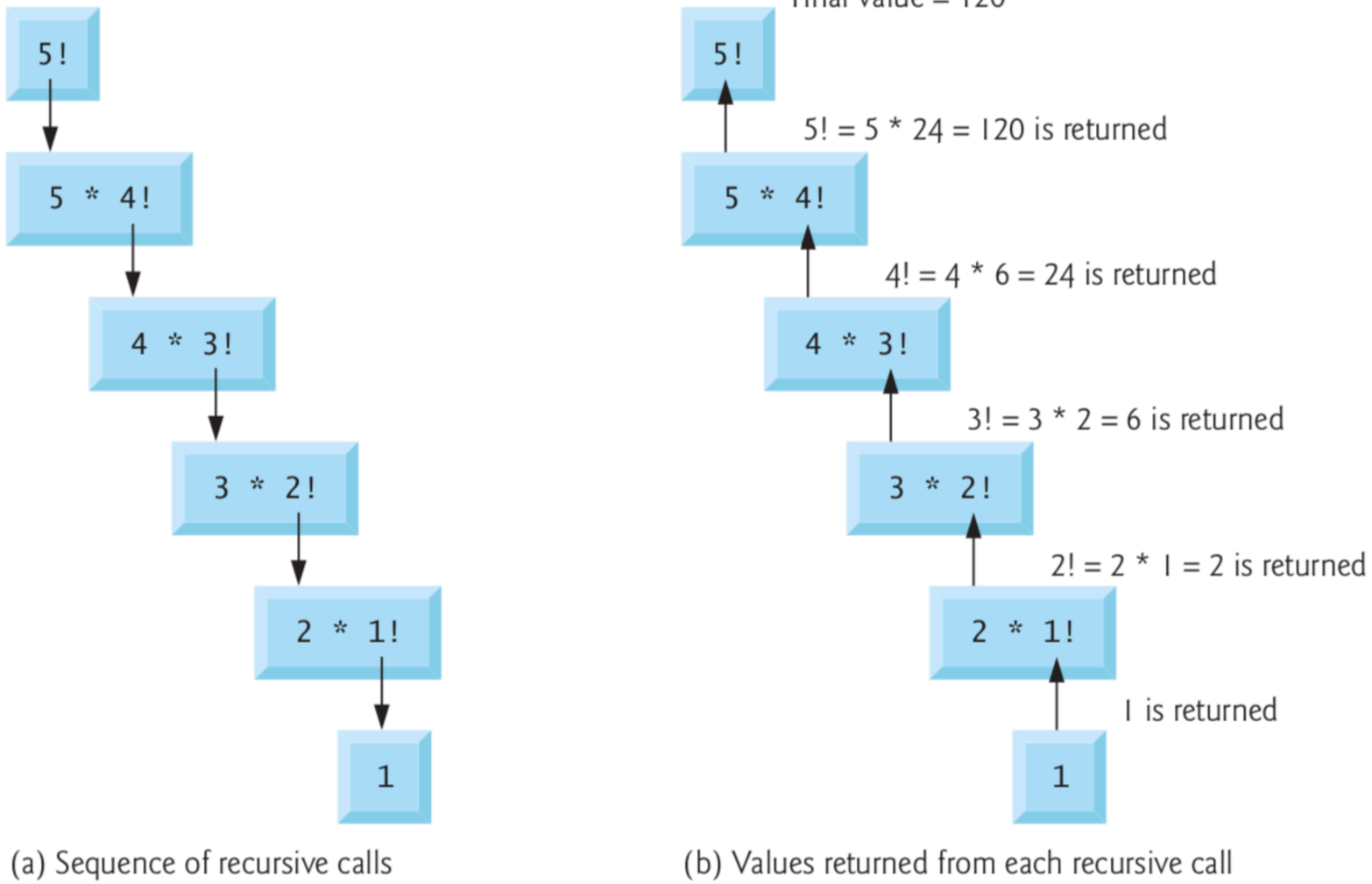
★ For example, 5! is clearly equal to 5 * 4! as is shown by the following:

$$5! = 5 \times 4 \times 3 \times 2 \times 1$$

$$5! = 5 \times (4 \times 3 \times 2 \times 1)$$

$$5! = 5 \times 4!$$

Factorial



(a) Sequence of recursive calls

(b) Values returned from each recursive call

Factorial function

```
1  // Fig. 5.18: fig05_18.c
2  // Recursive factorial function.
3  #include <stdio.h>
4
5  unsigned long long int factorial( unsigned int number );
6
7  // function main begins program execution
8  int main( void )
9  {
10    unsigned int i; // counter
11
12    // during each iteration, calculate
13    // factorial( i ) and display result
14    for ( i = 0; i <= 21; ++i ) {
15       printf( "%u! = %llu\n", i, factorial( i ) );
16    } // end for
17 } // end main
18
19 // recursive definition of function factorial
20 unsigned long long int factorial( unsigned int number )
21 {
22    // base case
23    if ( number <= 1 ) {
24       return 1;
25    } // end if
26    else { // recursive step
27       return ( number * factorial( number - 1 ) );
28    } // end else
29 } // end function factorial
```

Function Prototype

Function Call

Function Declaration

Base Case

Recursive Case

Factorial function

```
1  // Fig. 5.18: fig05_18.c
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23    if ( number <= 1 ) {
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25    } // end if
26    else { // recursive step
27       return ( number * factorial( number - 1 ) );
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29 } // end function factorial
```

```
0! = 1
1! = 1
2! = 2
3! = 6
4! = 24
5! = 120
6! = 720
7! = 5040
8! = 40320
9! = 362880
10! = 3628800
11! = 39916800
12! = 479001600
13! = 6227020800
14! = 87178291200
15! = 1307674368000
16! = 20922789888000
17! = 355687428096000
18! = 6402373705728000
19! = 121645100408832000
20! = 2432902008176640000
21! = 14197454024290336768
```

Fibonacci

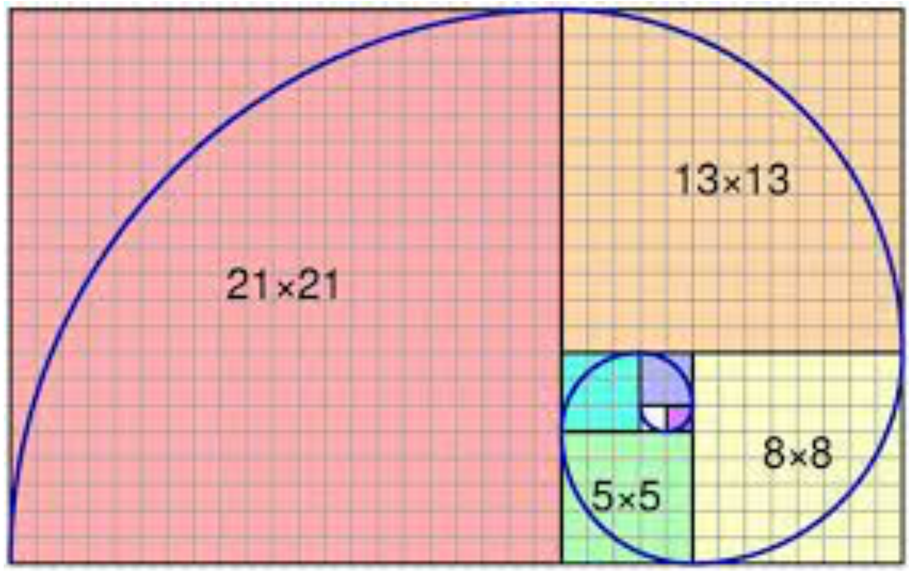
- Fibonacci (1170 – c. 1240–50), also known as Leonardo Bonacci, Leonardo of Pisa, or Leonardo Bigollo Pisano ('Leonardo the Traveller from Pisa'[7]), was an Italian mathematician from the Republic of Pisa, considered to be "the most talented Western mathematician of the Middle Ages".

Fibonacci

- The Fibonacci series

0, 1, 1, 2, 3, 5, 8, 13, 21, ...

- begins with 0 and 1 and has the property that each subsequent Fibonacci number is the sum of the previous two Fibonacci numbers.
- Golden Ratio



Fibonacci

- fibonacci(0) = 0
- fibonacci(1) = 1
- fibonacci(n) = fibonacci(n – 1) + fibonacci(n – 2)

✳ calculates the nth Fibonacci number recursively using function fibonacci.
Notice that Fibonacci numbers tend to become large quickly.

Fibonacci

```
1  // Fig. 5.19: fig05_19.c
2  // Recursive fibonacci function
3  #include <stdio.h>
4
5  unsigned long long int fibonacci( unsigned int n ); // function prototype
6
7  // function main begins program execution
8  int main( void )
9  {
10    unsigned long long int result; // fibonacci value
11    unsigned int number; // number input by user
12
13    // obtain integer from user
14    printf( "%s", "Enter an integer: " );
15    scanf( "%u", &number );
16
17    // calculate fibonacci value for number input by user
18    result = fibonacci( number );
19
20    // display result
21    printf( "Fibonacci( %u ) = %llu\n", number, result );
22 } // end main
23
24 // Recursive definition of function fibonacci
25 unsigned long long int fibonacci( unsigned int n )
26 {
27    // base case
28    if ( 0 == n || 1 == n ) {
29       return n;
30    } // end if
31    else { // recursive step
32       return fibonacci( n - 1 ) + fibonacci( n - 2 );
33    } // end else
34 } // end function fibonacci
```

Function Prototype

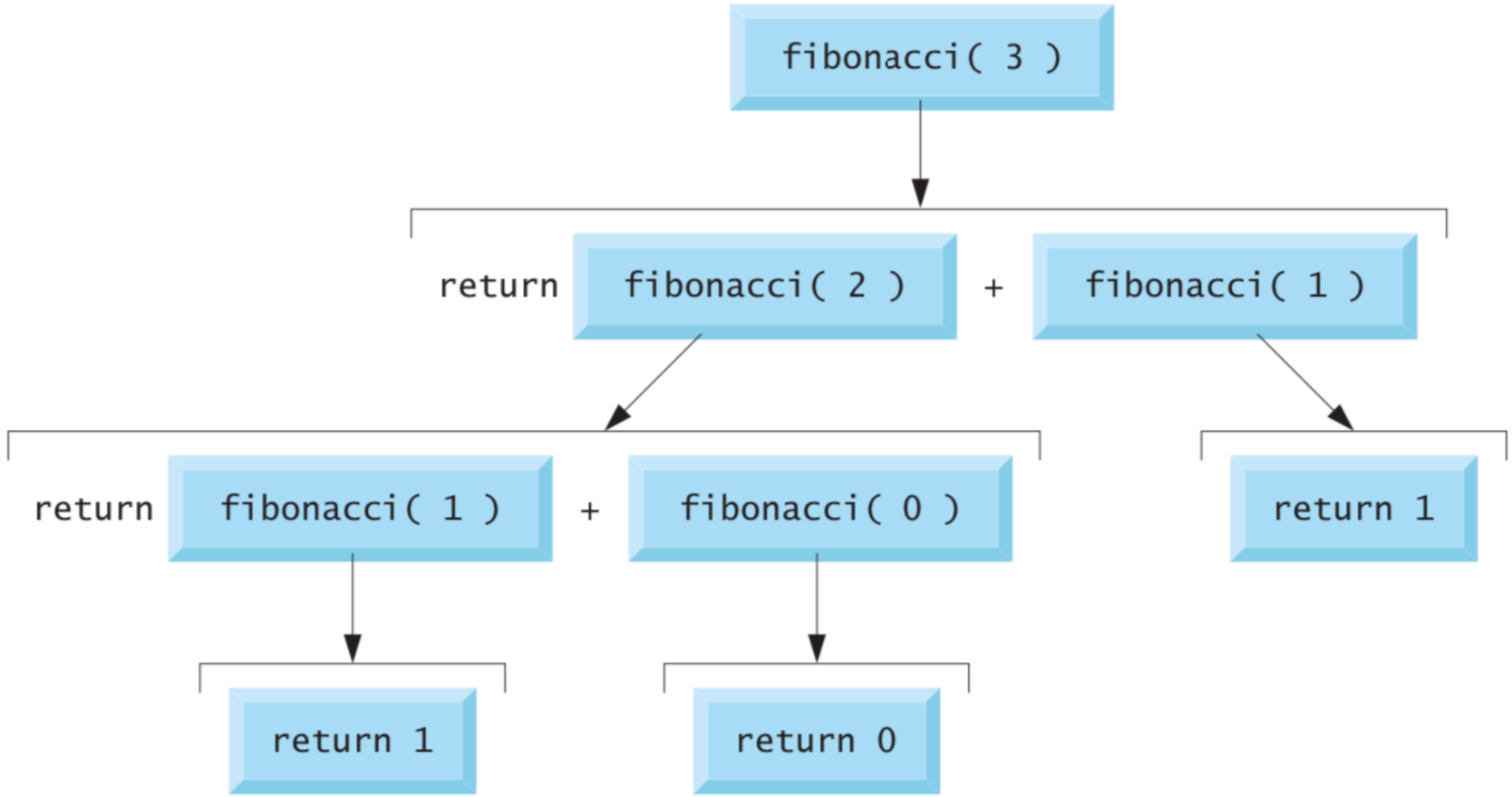
Function Call

Function Declaration

Base Case

Recursive Case

Fibonacci


fibonacci(3)
return
fibonacci(2)
+
fibonacci(1)
return
fibonacci(1)
+
fibonacci(0)
return 1
return 1
return 0

Question and Answer