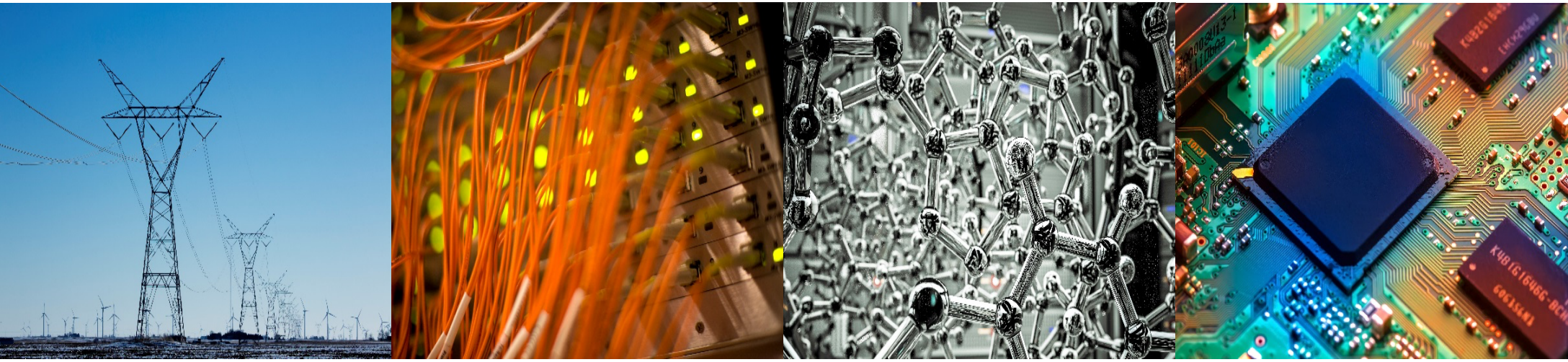
ECE 220 Computer Systems & Programming

Lecture 9 – Functions in C & Run-Time Stack

February 23, 2020



- MT1 is scheduled on Thursday, 3/4, 7 – 8:50pm CT
- Conflict exam is Friday, 3/5, 8am CT

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Nested Loops (from Lecture 8)

```
#include <stdio.h>
/* use nested for loops to print an n x n identity matrix */

#define N 5
int main(){
   int row, col;









   return 0;
}
```

Follow-up Questions

- What are some ways to stop after printing the third ’1’ on the main diagonal, such as the example below?

  1 0 0 0 0

  0 1 0 0 0

  0 0 1

- How can we take user input for the value of n?

- How can we add a check before printing the matrix to ensure user input is within the valid range of 0 < n < 10? (If user input is invalid, print the message “Number entered is invalid” and prompt the user to enter a number again.)

C Functions

Provides abstraction

- hide low-level details
- give high-level structure to program, easier to understand overall program flow
- enable separable, independent development
- reuse code

Structure of a function

- zero or multiple arguments passed in
- single result returned (optional)
- return value is always a particular type

Making a Function Call in C

```
#include <stdio.h>
/* our Factorial function prototype goes here */
int Fact(int n);

/* main function */
int main() {
   int number;
   int answer;

   printf("Enter a number: ");
   scanf("%d", &number);

   answer = Fact(number); /* function call */
   /* number – argument transferred from main to Factorial */
      answer – return value from Factorial to main */

   printf("factorial of %d is %d\n", number, answer);

   return 0;
}
```

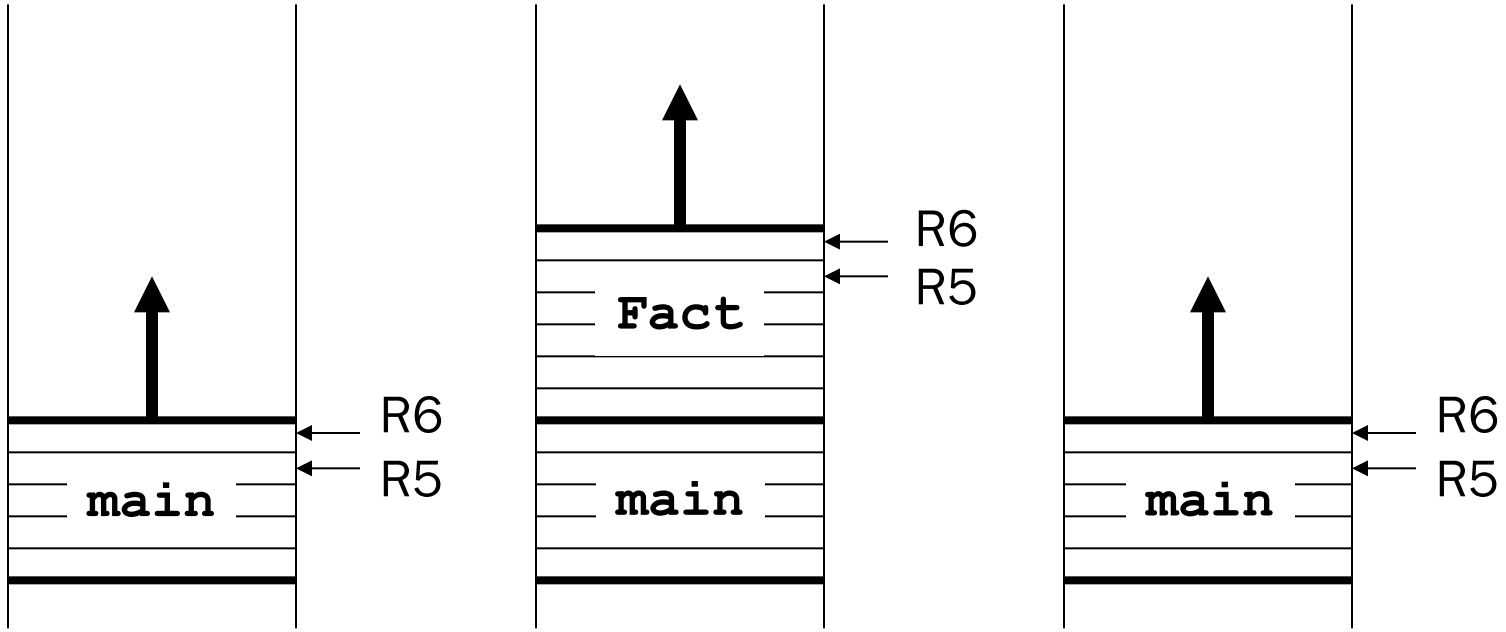
```
/* implementation of Factorial function goes here */
int Fact(int n) {
   int i, result=1; /* local variables in Factorial */

   for (i = 1; i <= n; i++)
      result = result * i;

   return result; /* return value */
}
```

Run-Time Stack

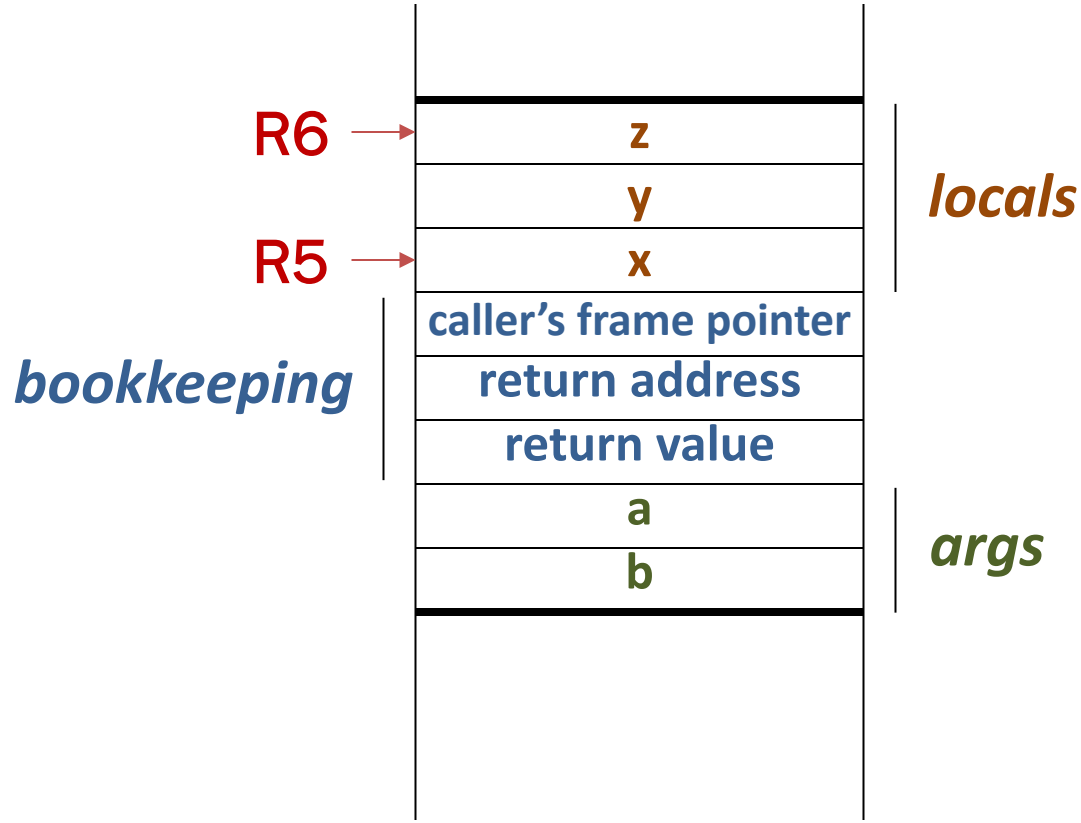
- R5 – **Frame Pointer**. It points to the beginning of a region of activation record that stores local variables for the current function.
- R6 – **Stack Pointer**. It points to the **top most occupied location** on the stack.
- In LC-3, arguments are pushed to the stack _____, local variables are pushed to the stack _____.



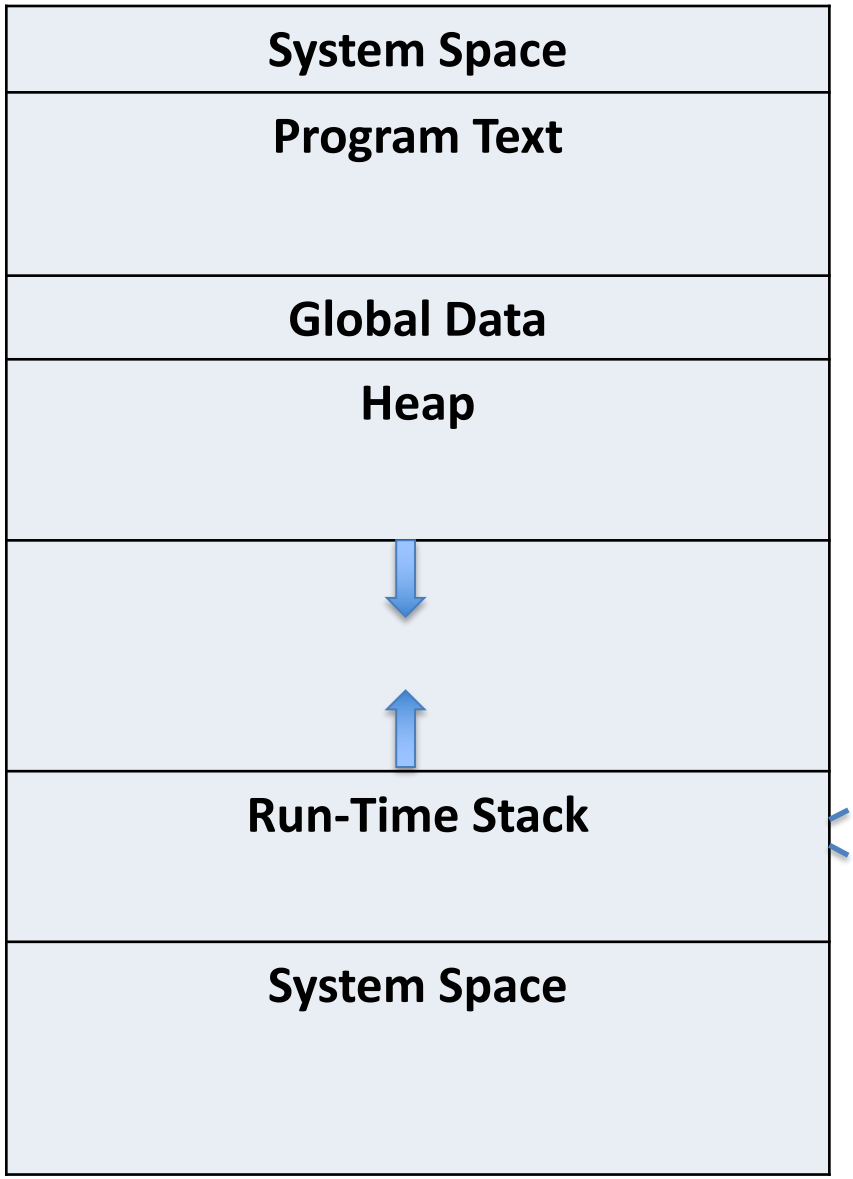
Before call *During call* *After call*

Activation Record

```
int func(int a, int b){
   int x, y, z;
   .
   .
   .
   return y;
}
```



Memory Organization



Activation Record

- Local Variables
- Bookkeeping Information:
  - Caller's Frame Pointer
  - Return Address
  - Return Value
- Arguments

Stack Built-up and Tear-down

Caller function	**1. caller setup** (push callee's arguments onto stack)
	2. pass control to callee (invoke function)
Callee function	**3. callee setup** (push bookkeeping info and local variables onto stack)
	4. execute function
	5. callee teardown (pop local variables, caller's frame pointer, and return address from stack)
	6. return to caller
Caller function	**7. caller teardown** (pop callee's return value and arguments from stack)

Run-Time Stack Exercise

```
#include <stdio.h>
int Fact(int n);

int main() {
   int number;
   int answer;
   …
   answer = Fact(number);
   …
   return 0;
}

int Fact(int n) {
   int i, result=1;

   for (i = 1; i <= n; i++)
      result = result * i;

   return result;
}
```

x3FF7	
x3FF8	
x3FF9	
x3FFA	
x3FFB	
x3FFC	
x3FFD	
x3FFE	
x3FFF	answer
x4000	number

main's activation record