ECE 220

Lecture x0007 - 09/17

Slides based on material originally by: Yuting Chen & Thomas Moon

Recap

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  - Introduction to C language

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  - Come to class!

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`to_celsius` better return a float

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`to_celsius` is a C function and this is its ***function definition.***

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  - Enable separable and independent development
  - Reuse code

Math functions vs. C functions

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C is **not** a functional language!

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Function *declaration*

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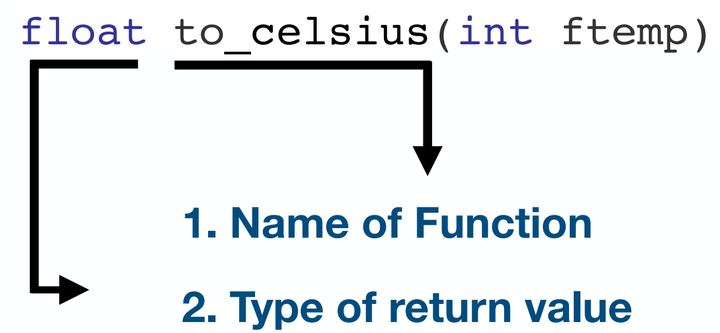

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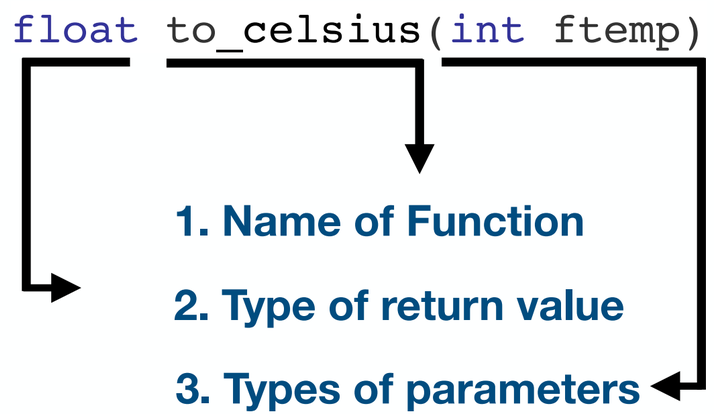

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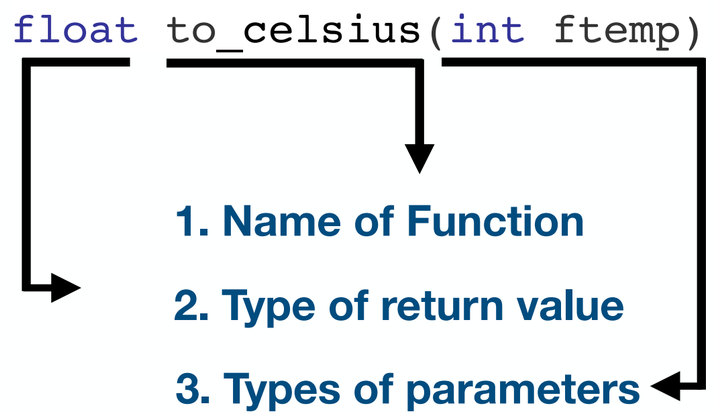

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Note: Function **declaration** (can be) different from **definition**

Also valid code

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In-fact recommended code

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A quick visualization

https://tinyurl.com/37avn3u5

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- Write a function which accepts an integer n as an argument and prints out a $n \times n$ identity matrix to the console.
  - Modify the function to make it print out a *lower triangular* **OR** *upper triangular* identity matrix like the ones below (shown for $n = 4$).

$$\begin{bmatrix} 1 & & & \\ 0 & 1 & & \\ 0 & 0 & 1 & \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad \begin{bmatrix} 1 & 0 & 0 & 0 \\ & 1 & 0 & 0 \\ & & 1 & 0 \\ & & & 1 \end{bmatrix}$$

Exercises

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Yes		
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  - Pass in extra argument to specify which type of matrix should be printed, then
  - Use appropriate logic depending on argument

Back to functions: deeper at assembly level

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int inGlobal=2;
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Let us go over this line by line

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Name	Type	Location	Scope

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Symbol table

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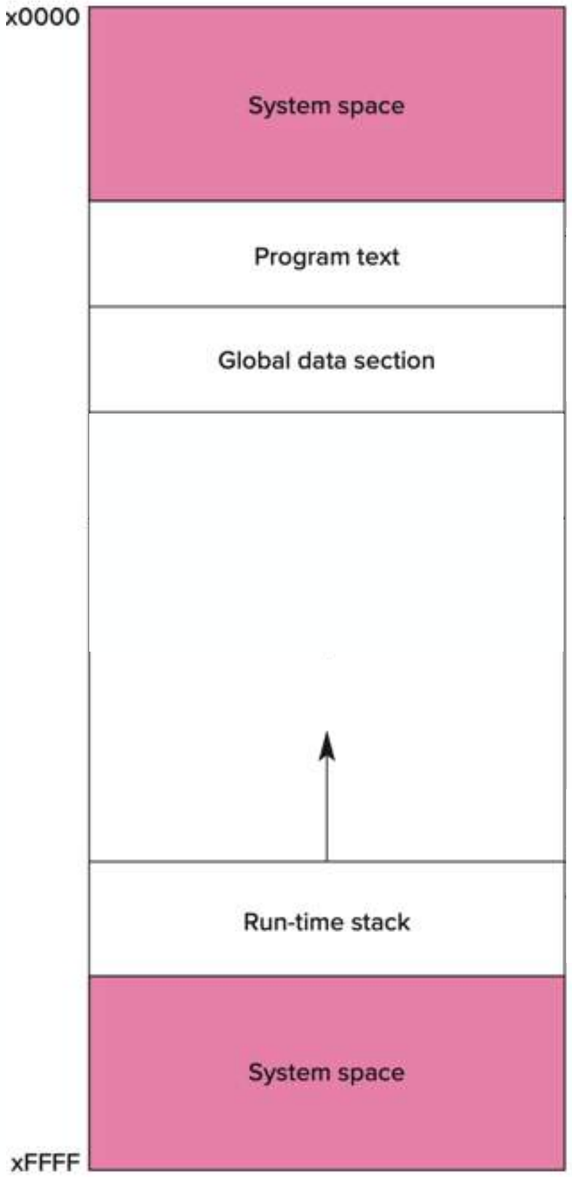
Where in memory are these stored?

Example: In LC3 memory map



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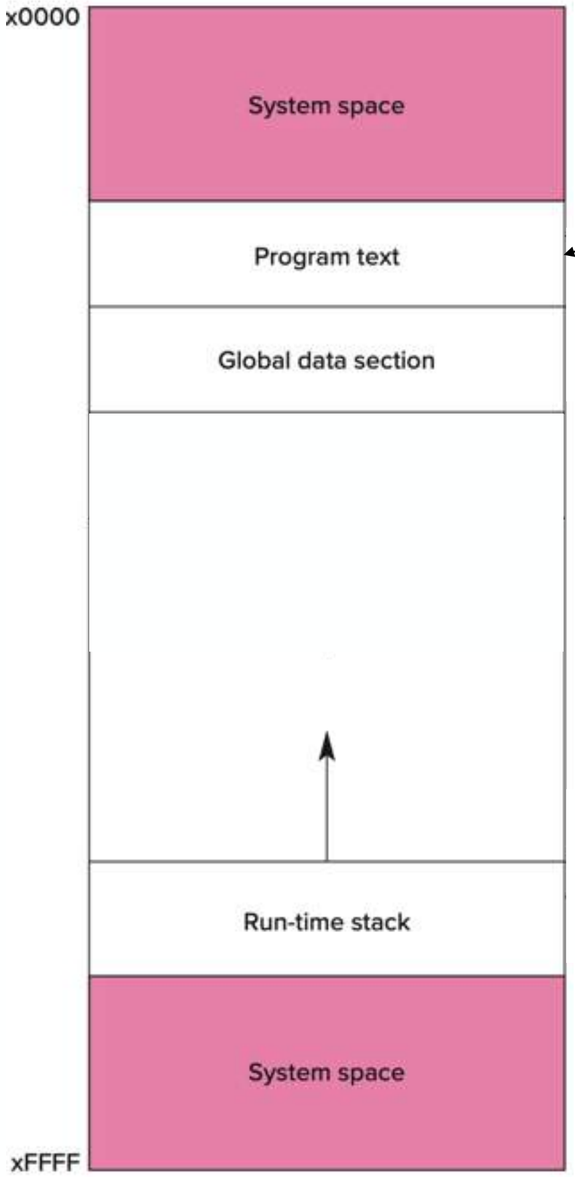


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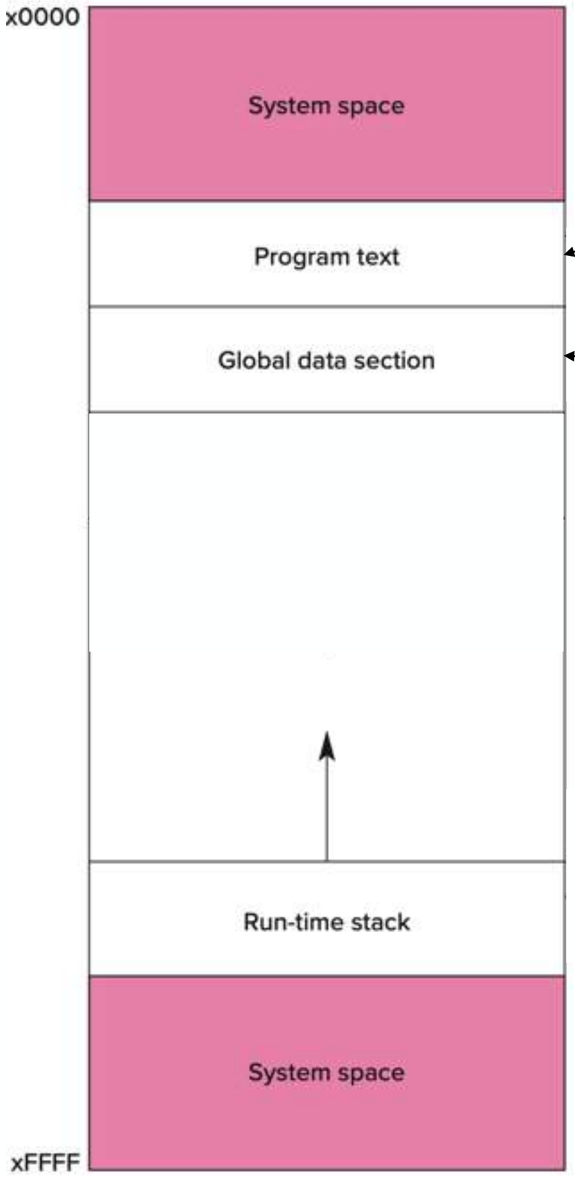


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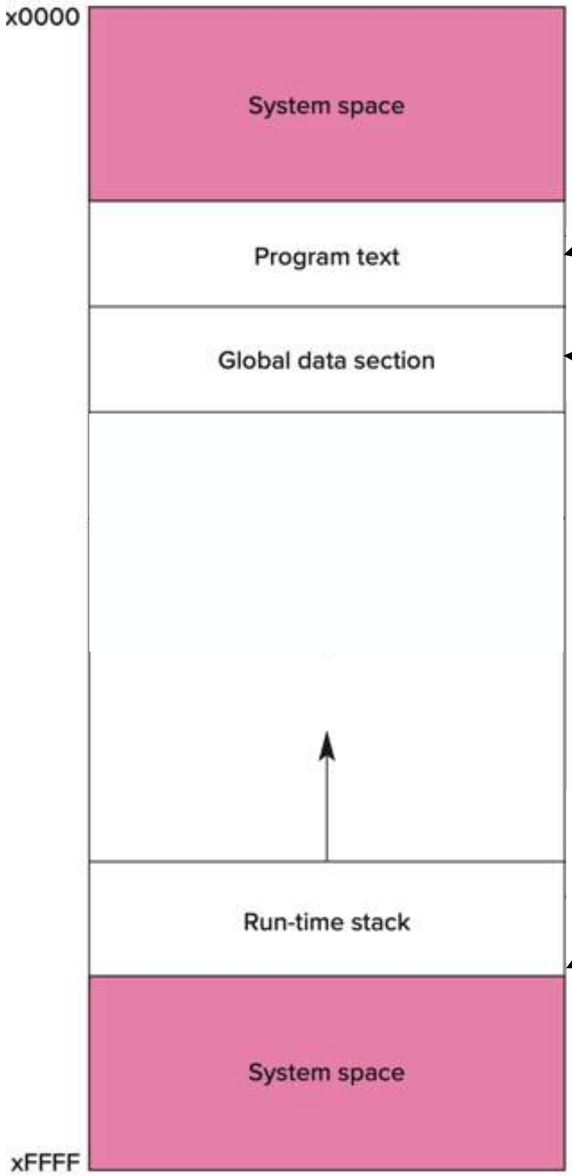


```c
int inGlobal;
int outGlobal;
int dummy(int in1, int in2);

int main(void){
  int x,y,z;
  ...
}

int dummy(int in1, int in2){
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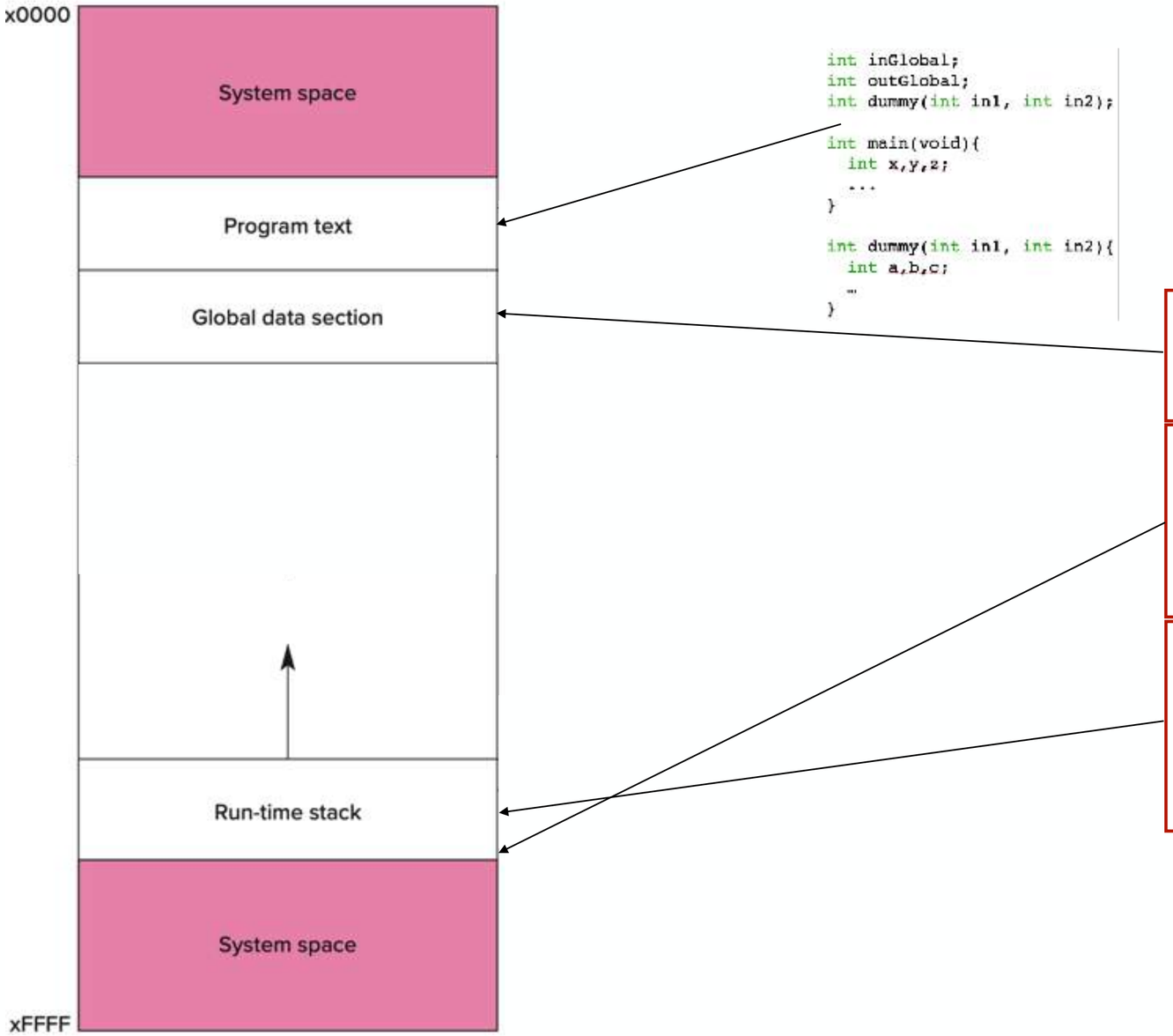


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  - Bookkeeping information

Getting this to work

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- Whenever a function *completes* (returns), the activation record is popped off the run-time stack

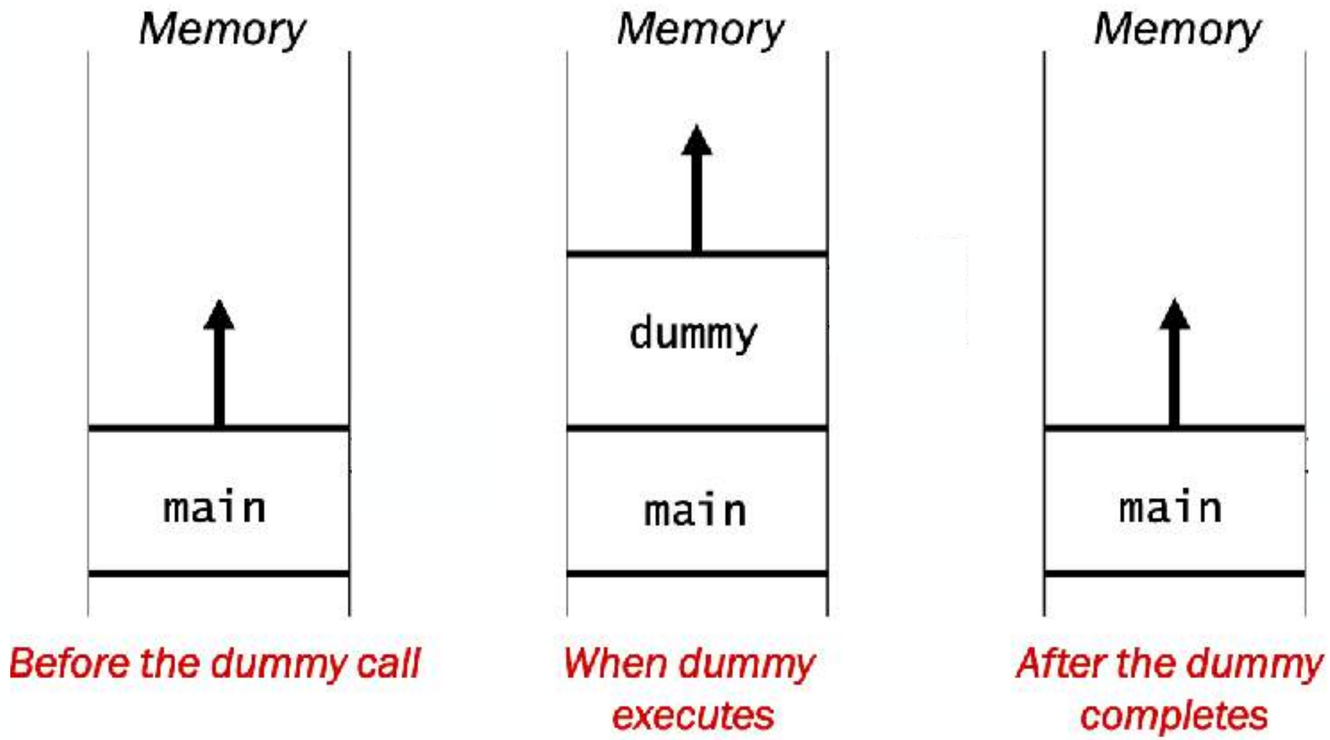
- Whenever a function calls *another one* (nested, including itself), the run time stack grows (pushes another activation record onto the run-time stack).

Example: function call

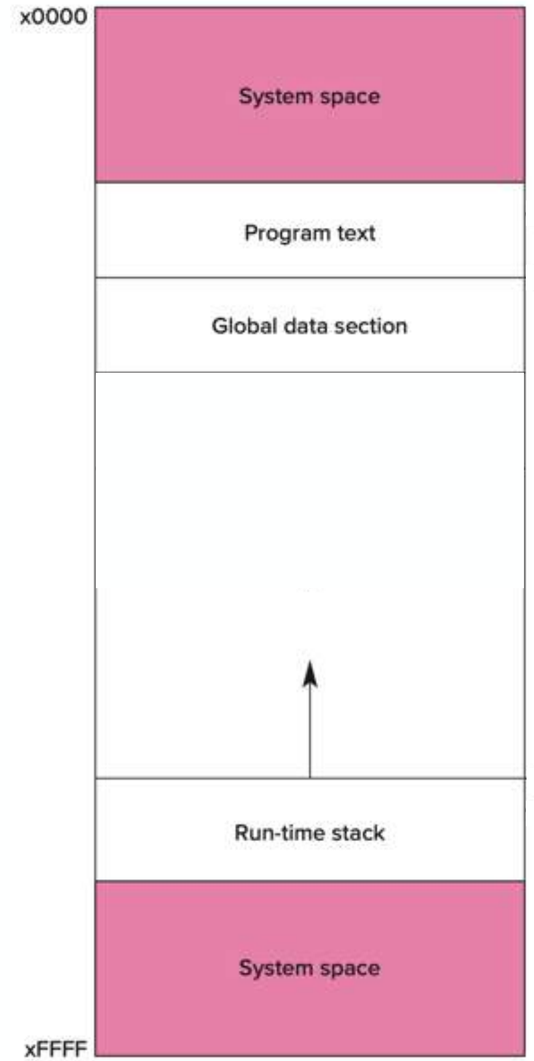
```
int dummy(int in1, int in2);

int main(void){
   int x,y,z;
   ...
   z = dummy(x, y);
}

int dummy(int in1, int in2){
   int a,b,c;
   …
}
```

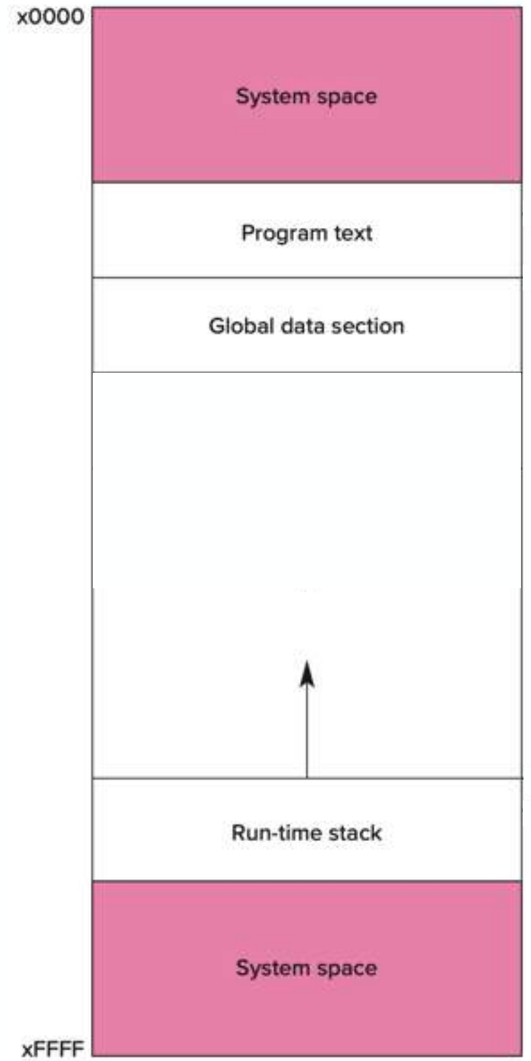


How to keep track?



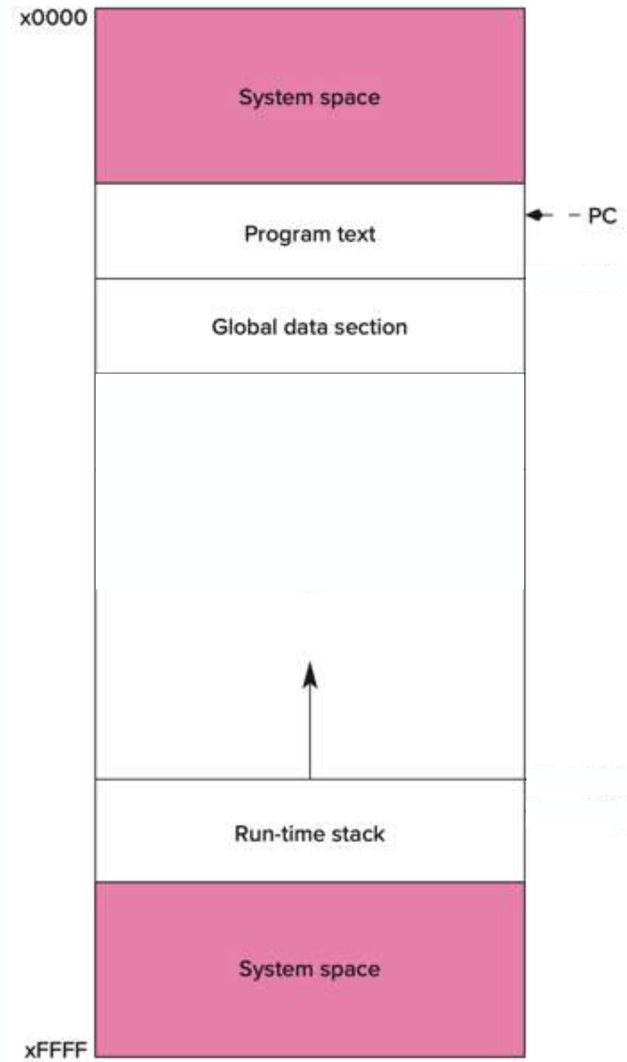
How to keep track?

- Store pointers:



How to keep track?

- Store pointers:
  - Program counter - PC



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- Store pointers:
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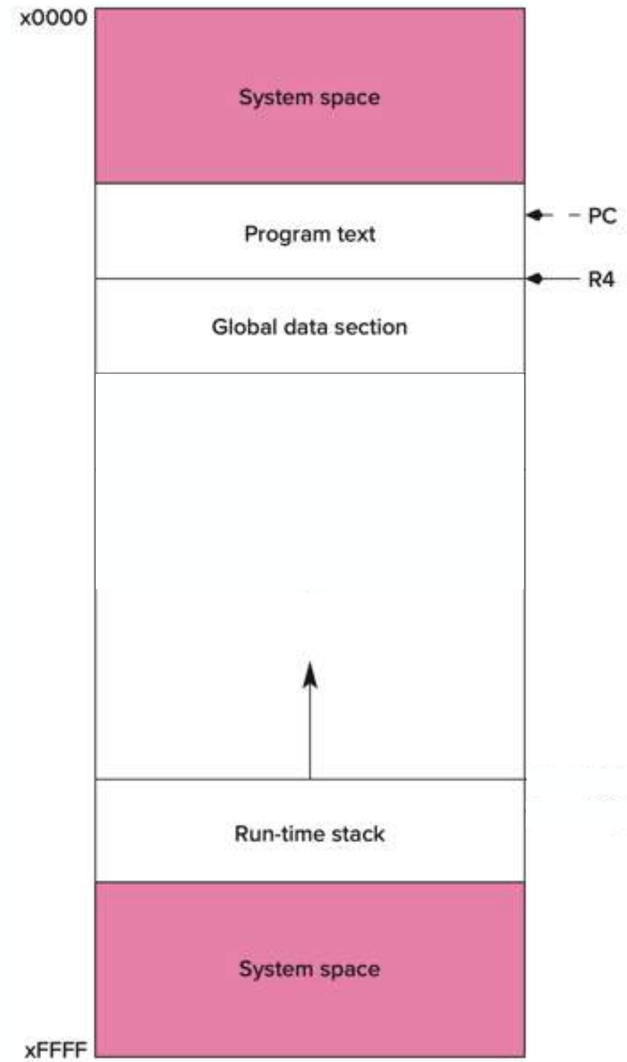

How to keep track?

- Store pointers:
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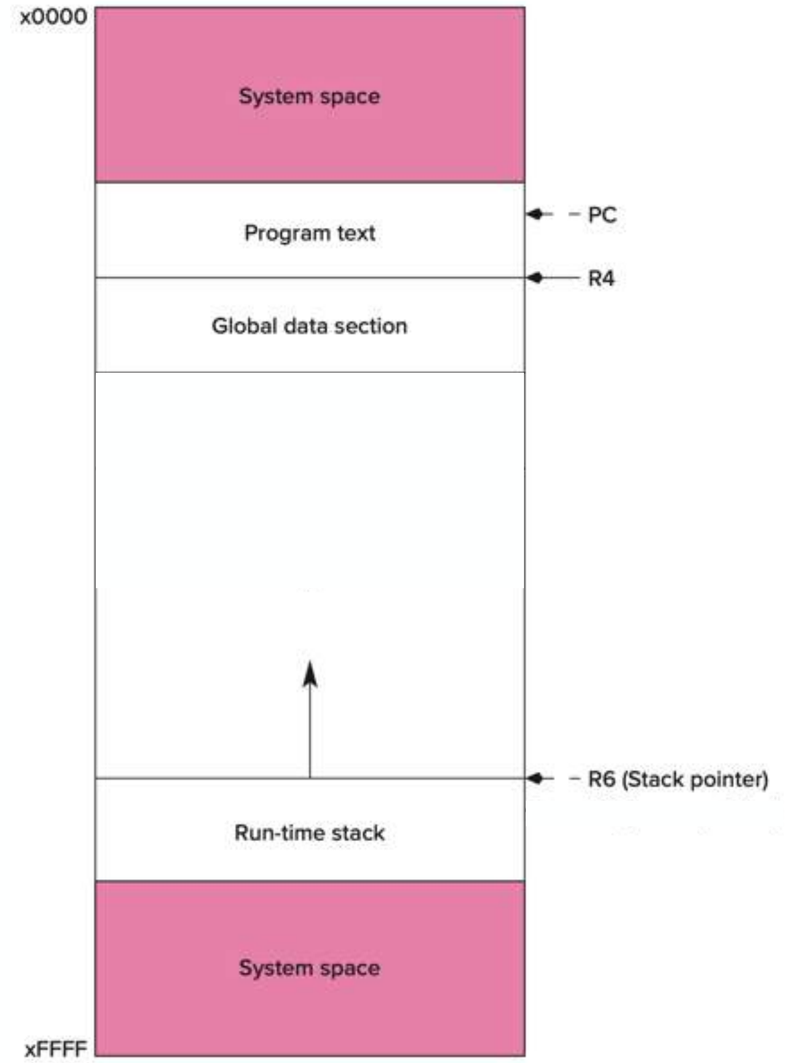
  - **Global pointer** pointing to first global variable - `R4`
  - Top of stack, called **stack pointer** - `R6`



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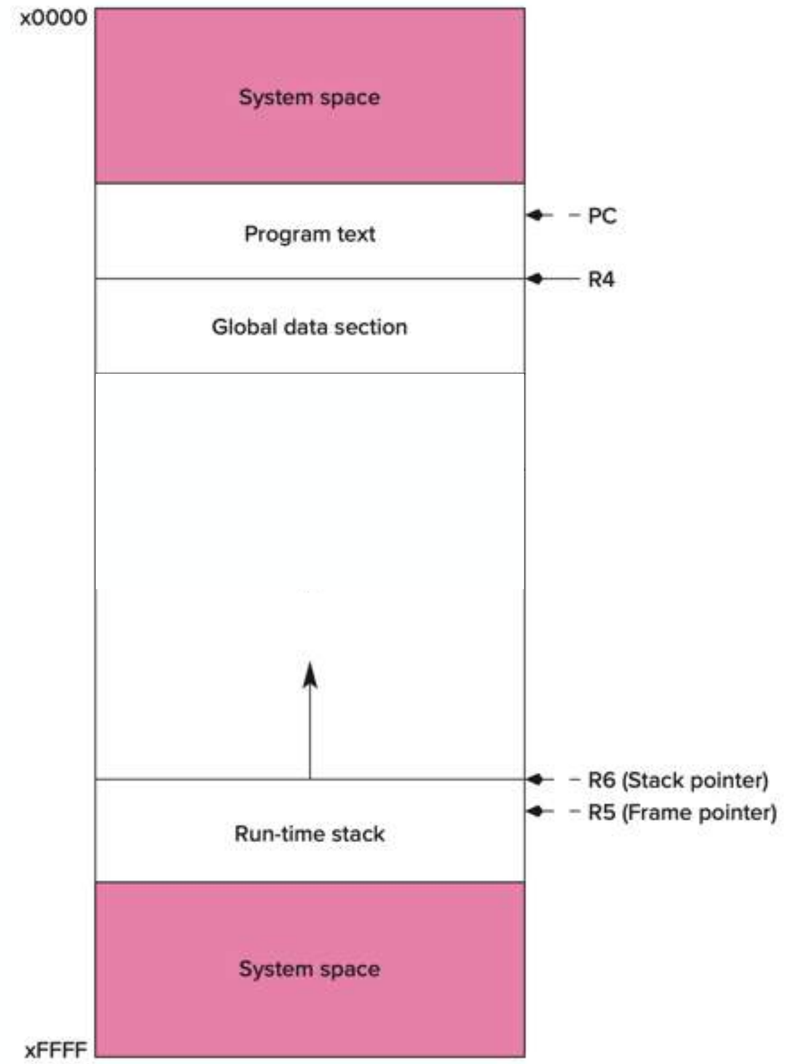

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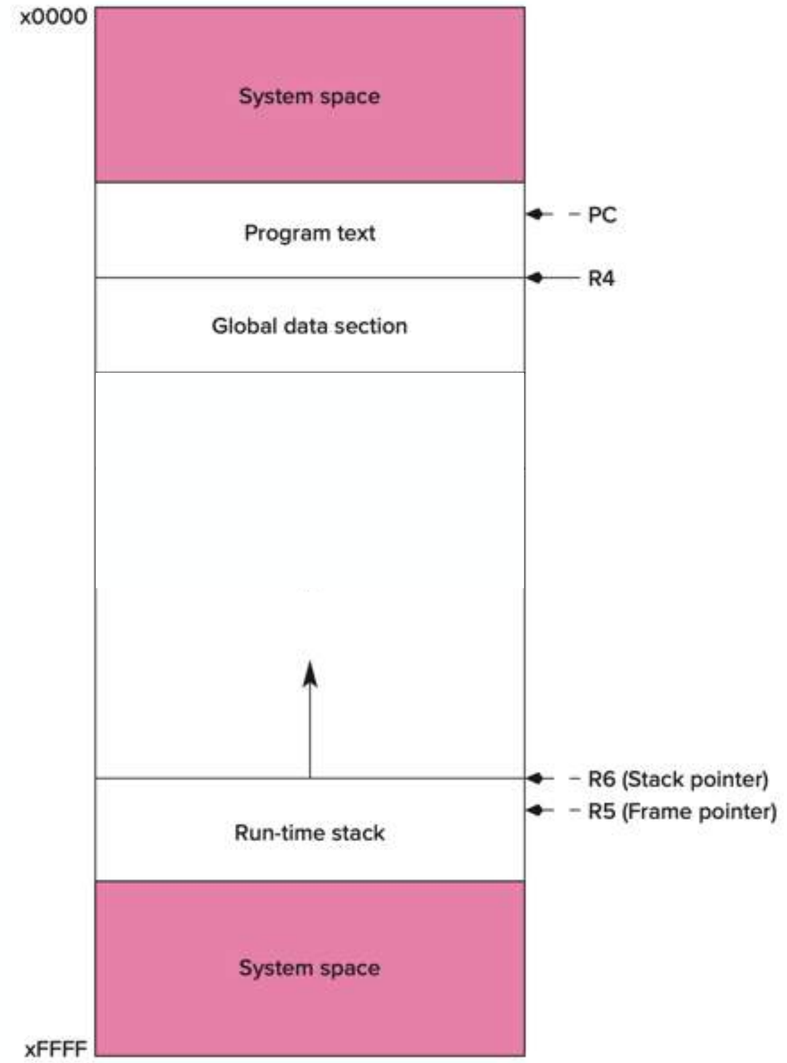
- Store pointers:
  - Program counter - PC
  - **Global pointer** pointing to first global variable - `R4`
- Top of stack, called **stack pointer** - `R6`
- *Current* **frame pointer** - `R5`
  - Actually points to first local variable of *current* function



Global variables use register `R4`

Example: global variables

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int inGlobal=2;
int outGlobal=0;
int dummy(int in1,

int main(void){
  int x,y,z;
  ...
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Name	Type	Location	Scope
inGlobal	int	0	Global
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```
AND R0, R0, #0
ADD R0, R0, #2
STR R0, R4, #0 ; inGlobal=2
```

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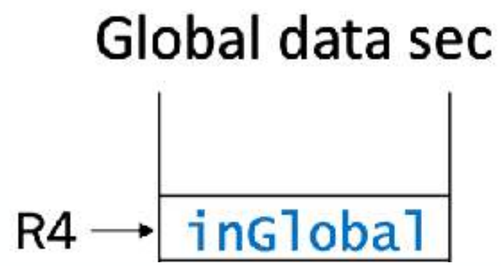

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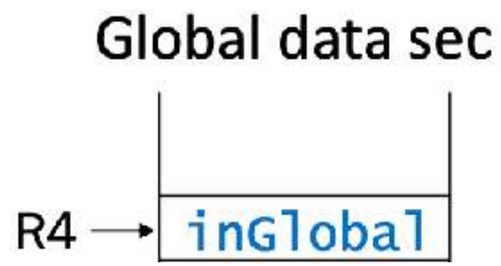

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AND R0, R0, #0
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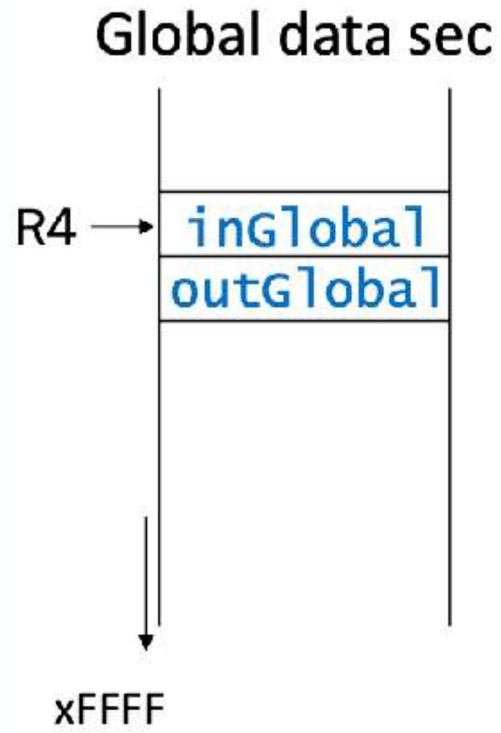

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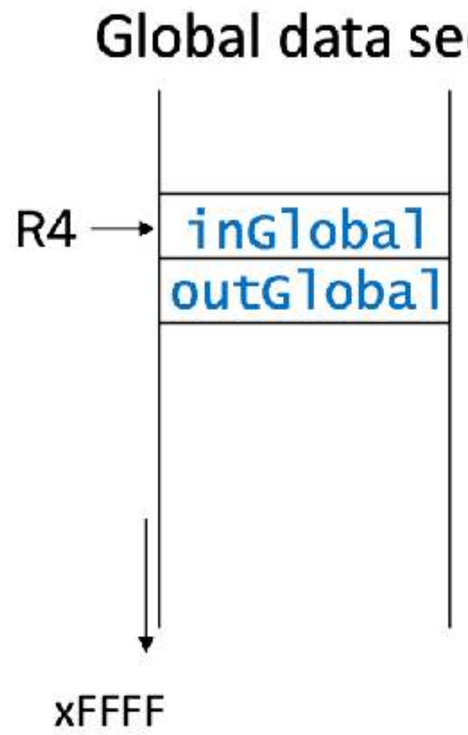

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```

R4 points
the first global variable

Local variables use register `R5`

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```
int inGlobal=2;
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   int x=3; // Value for e.g.
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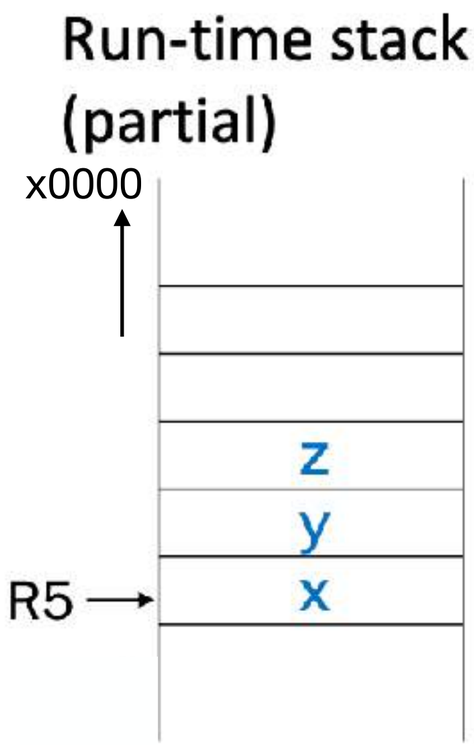
y	int	-1	Main

```
AND R0, R0, #0
ADD R0, R0, #3
STR R0, R5, #0   ; x = 3
AND R0, R0, #0
STR R0, R5, #-1  ; y = 0
```

Example: local variables



Name	Type	Location	Scope
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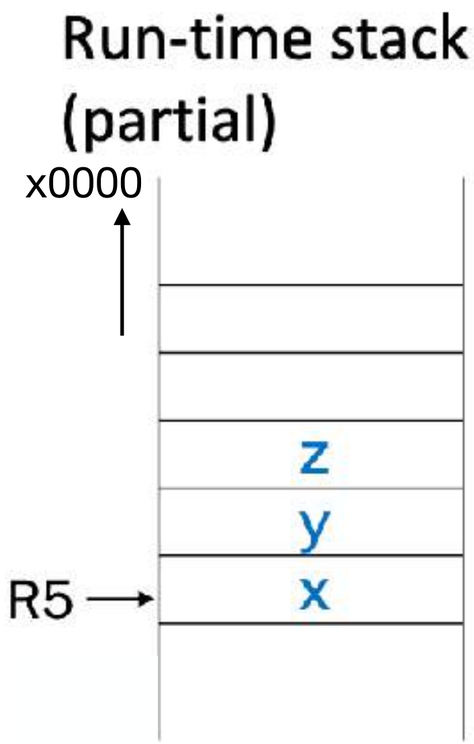

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R5 points
the first local variable

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    2. control is transferred to the callee
    3. the callee executes its task
    4. control is passed back to the caller, along with a return value

Example: function call

```
int dummy(int in1, int in2);

int main(void){
  int x,y,z;
  ...
  z = dummy(x, y);
}

int dummy(int in1, int in2){
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What happens when `main` calls `dummy`?

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An *activation record* or *stack-frame* is generated and **pushed** onto the runtime stack & execution transfers to `dummy`

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What happens when `main` calls `dummy`?

An *activation record* or *stack-frame* is generated and **pushed** onto the runtime stack & execution transfers to `dummy`

When `dummy` finishes execution its stack-frame is **popped** off and execution transfers back to `main`

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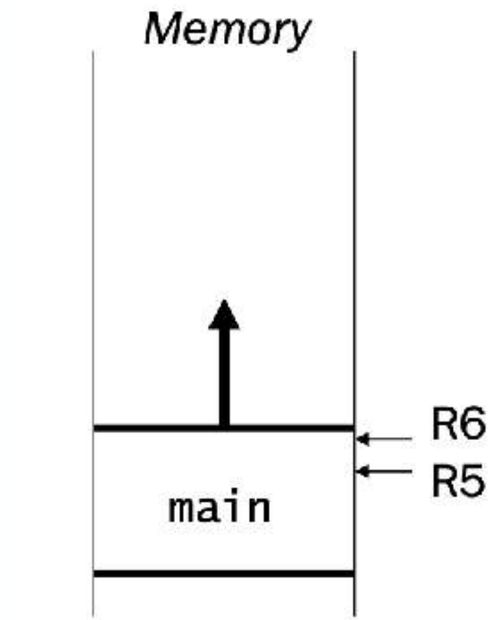

Before the dummy call

Example: function call

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int dummy(int in1, int in2);

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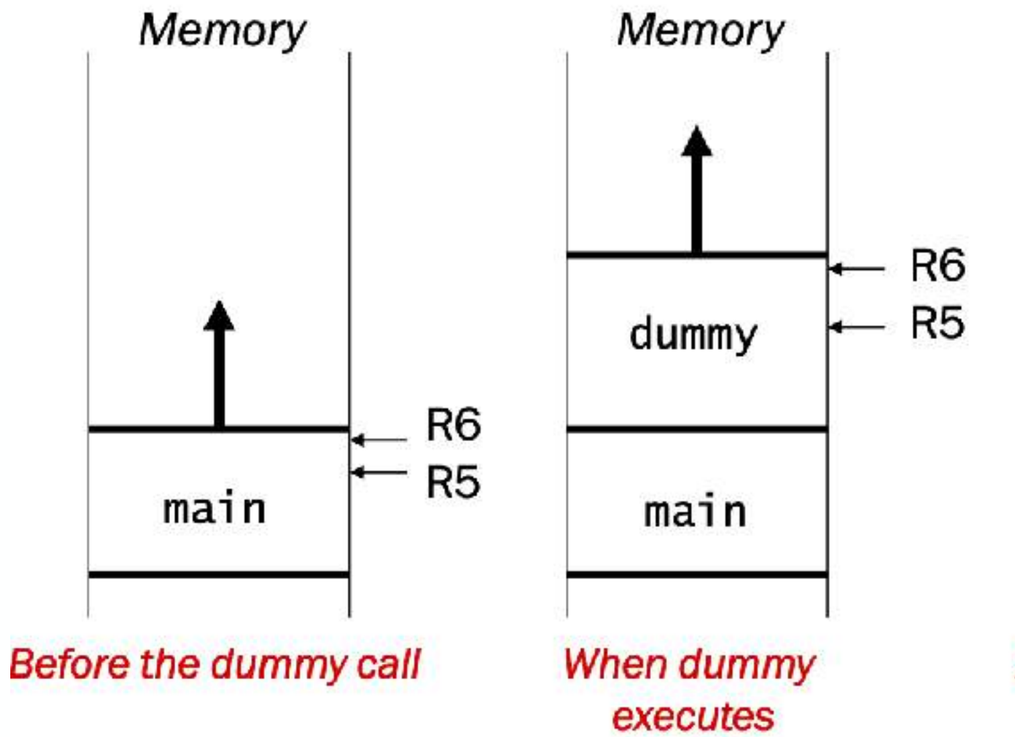

Before the dummy call

When dummy executes

Example: function call

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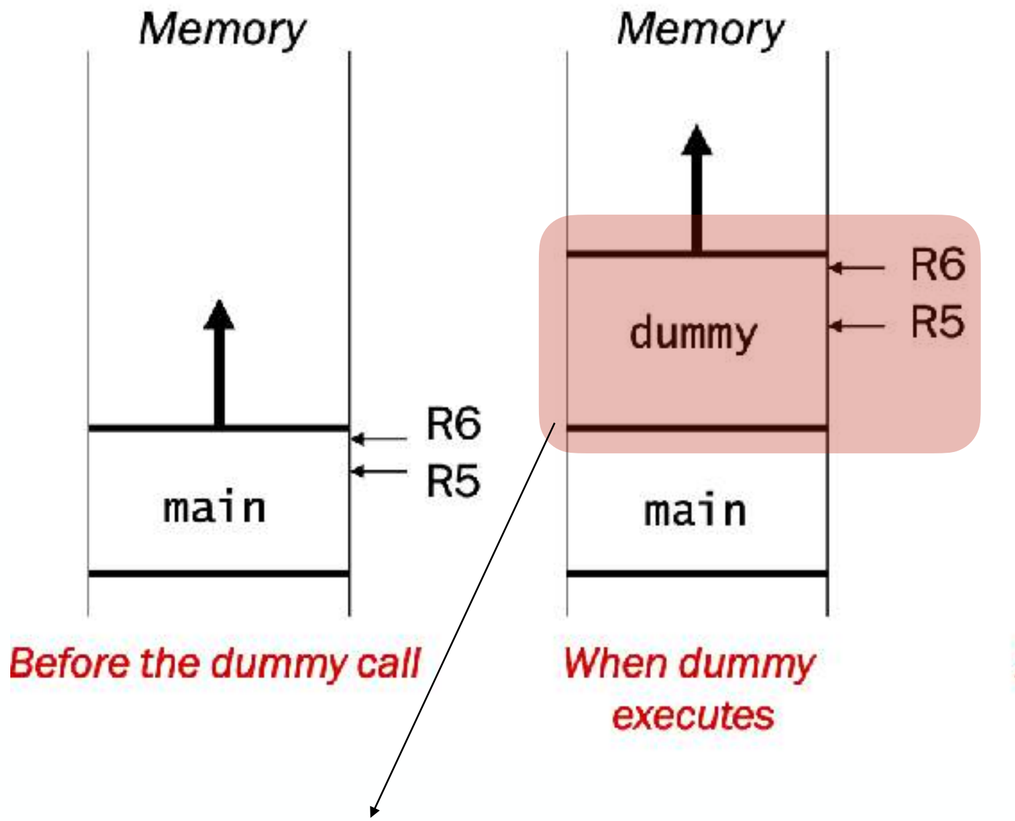

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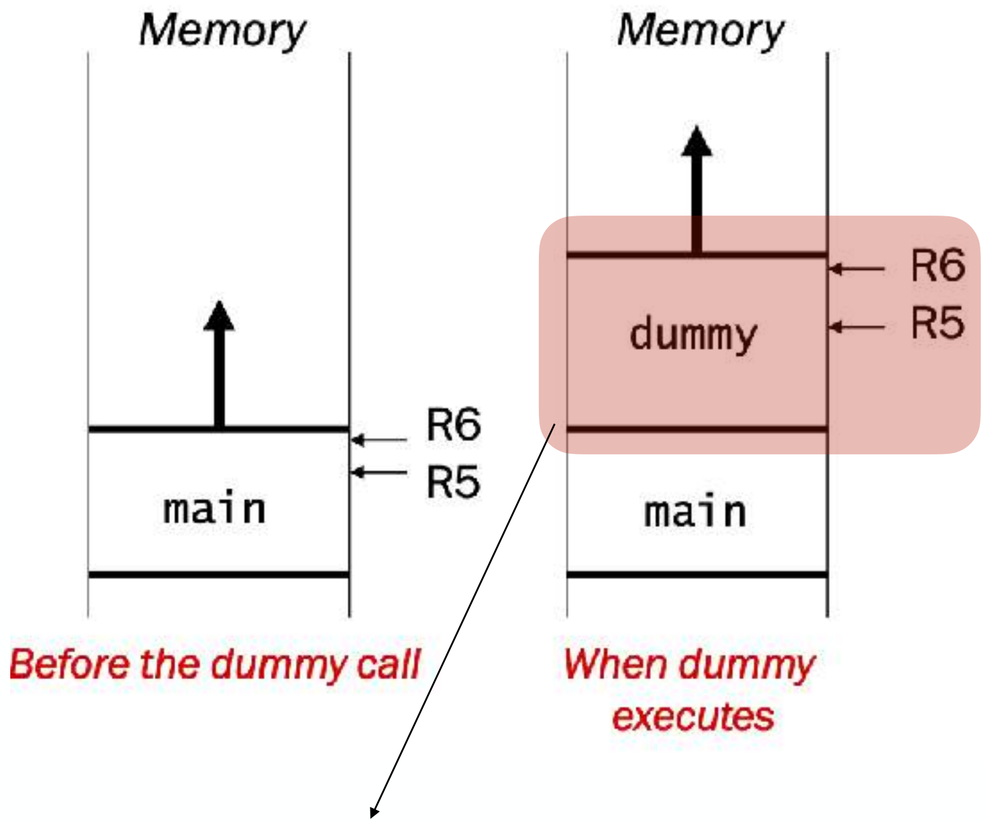

Note: R6 and R5 were duly updated

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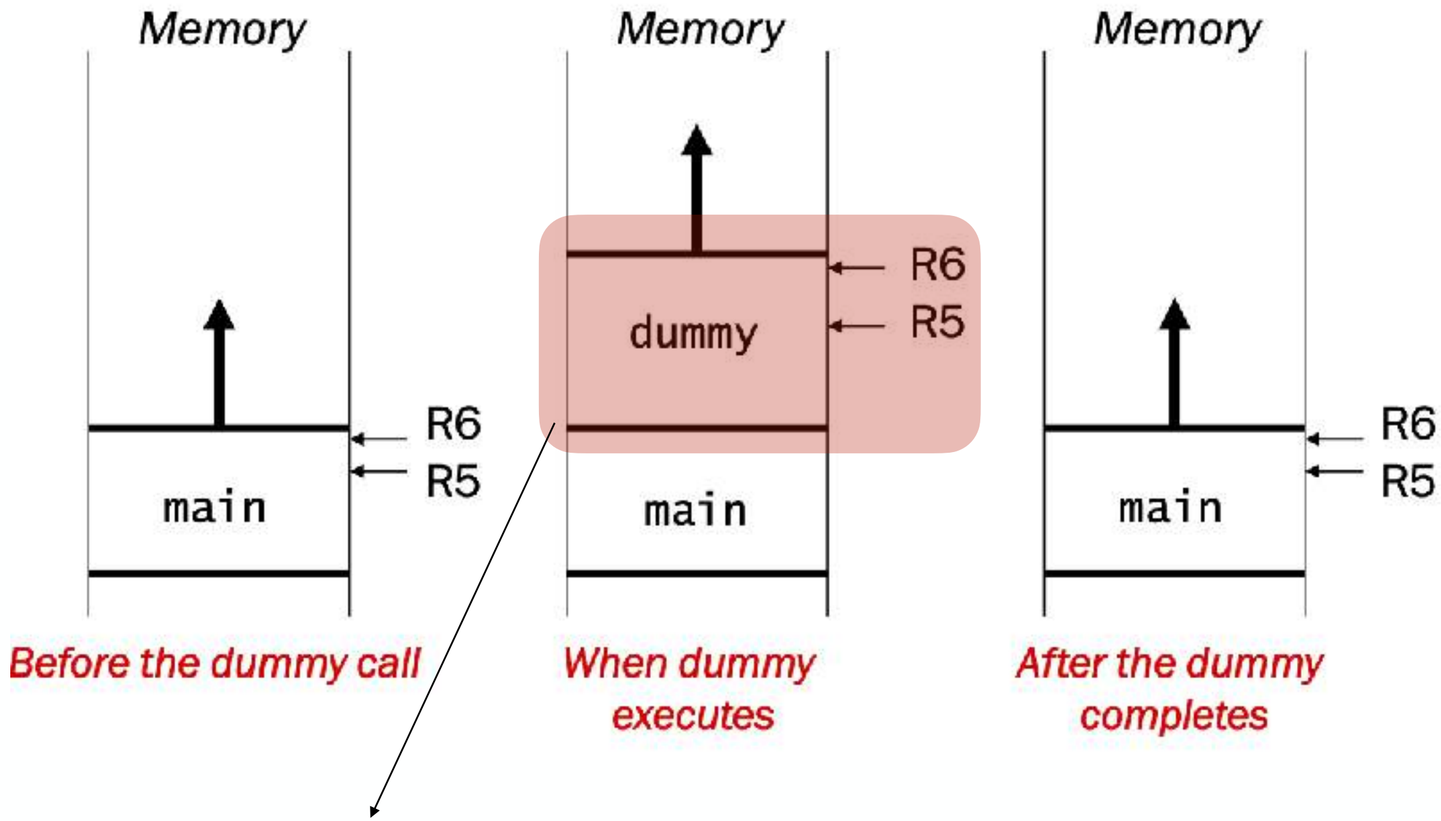

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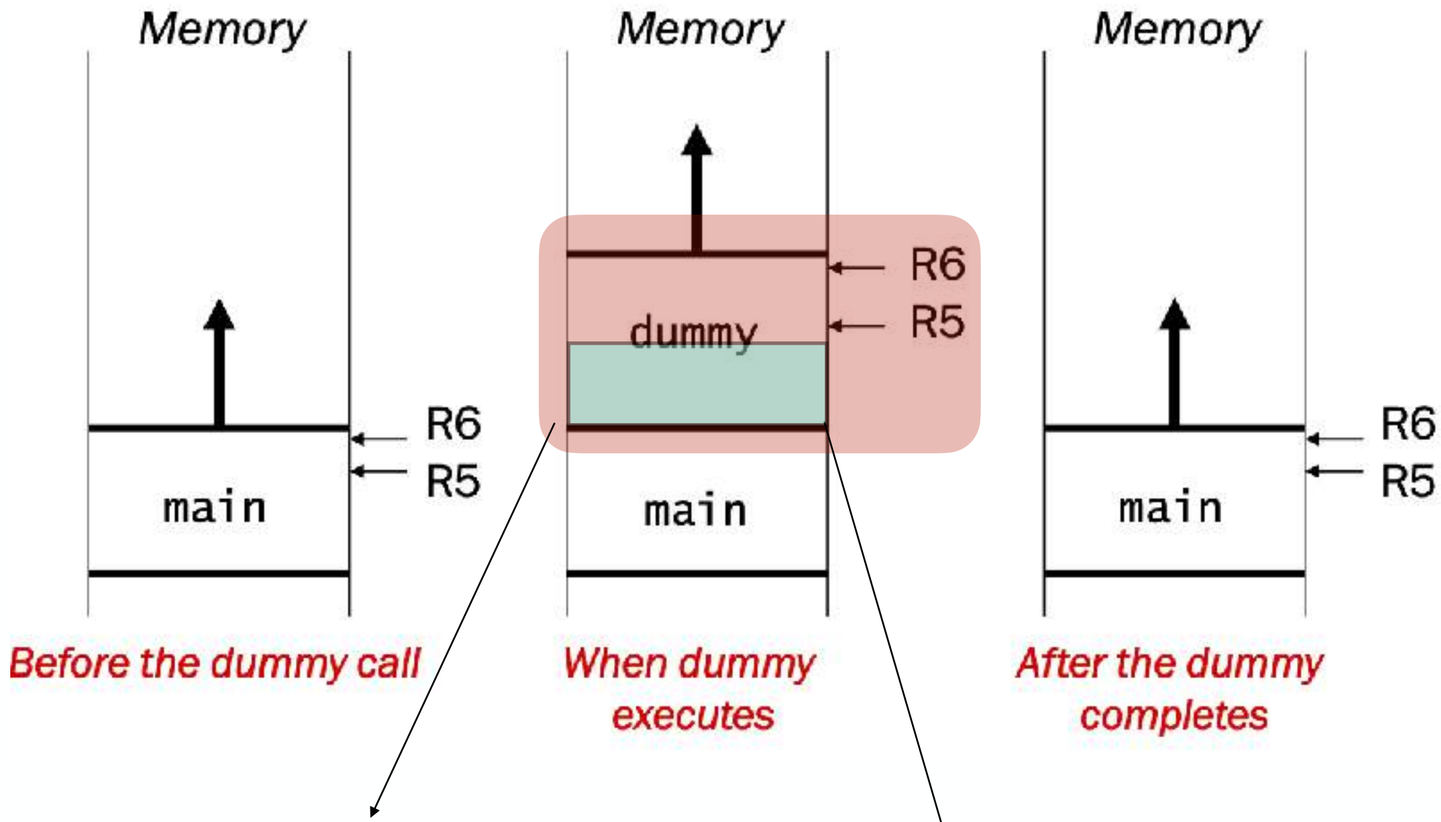

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Activation record

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- Callee build-up: (push bookkeeping info and local variables onto stack)

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- Callee build-up: (push bookkeeping info and local variables onto stack)
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Stack teardown

Callee

- *Caller tear-down* (pop callee's return value and arguments from stack)

Caller

Next time

- Stack build-up and stack tear-down

- Examples