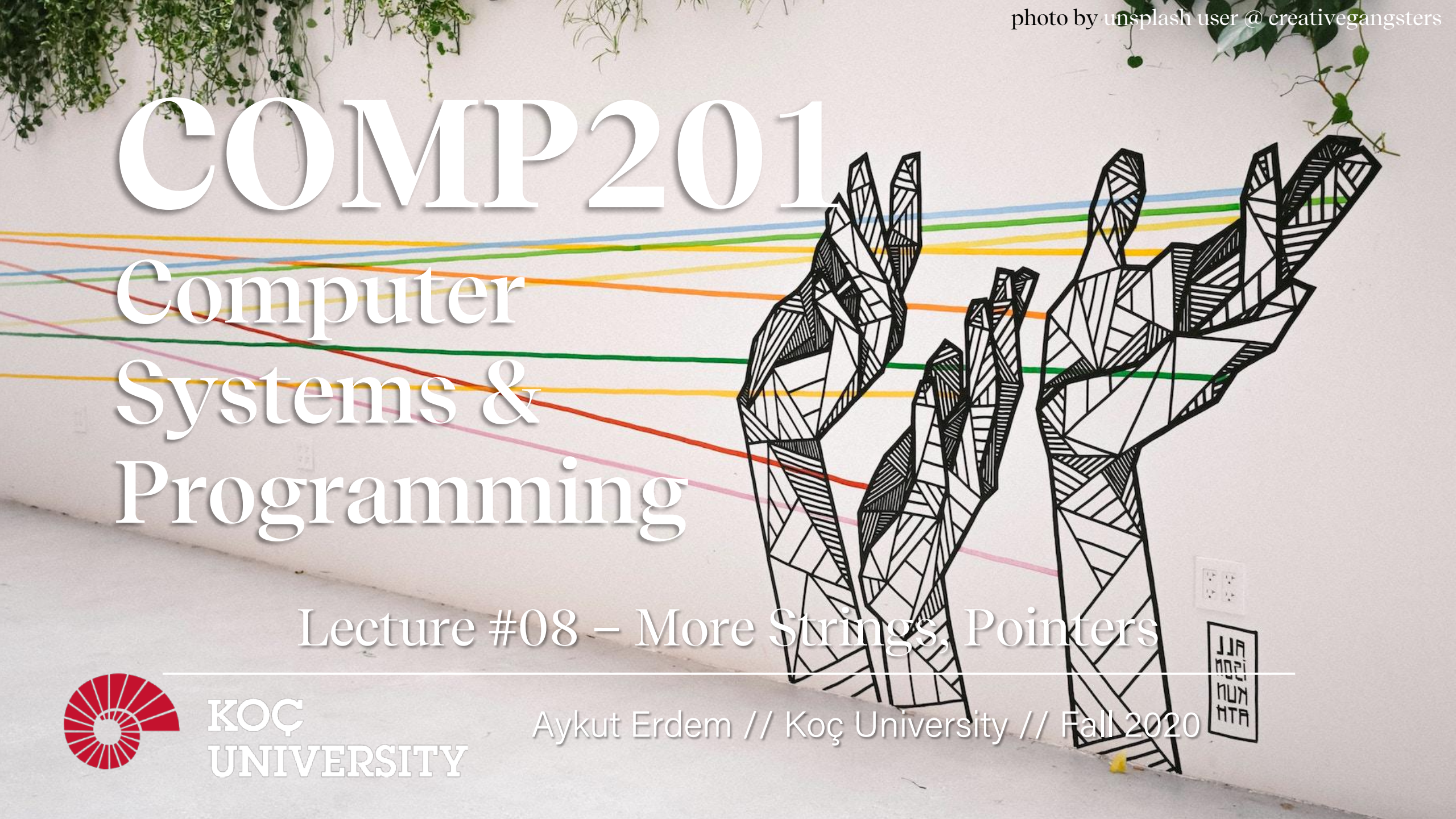


COMP201

Computer Systems & Programming

Lecture #08 – More Strings, Pointers

KOÇ UNIVERSITY

Aykut Erdem // Koç University // Fall 2020

Recap

- Characters
- Strings
- Common String Operations
  - Comparing
  - Copying
  - Concatenating
  - Substrings

Plan for Today

- String Diamond
- Searching in Strings
- Pointers

Disclaimer: Slides for this lecture were borrowed from

—Nick Troccoli's Stanford CS107 class

Lecture Plan

- String Diamond
- Searching in Strings
- Pointers

String Diamond

- Write a function **`diamond`** that accepts a string parameter and prints its letters in a "diamond" format as shown below.
  - For example, `diamond("COMP201")` should print:

```
C
CO
COM
COMP
COMP2
COMP20
COMP201
 OMP201
  MP201
   P201
    201
     01
      1
```

Practice: Diamond

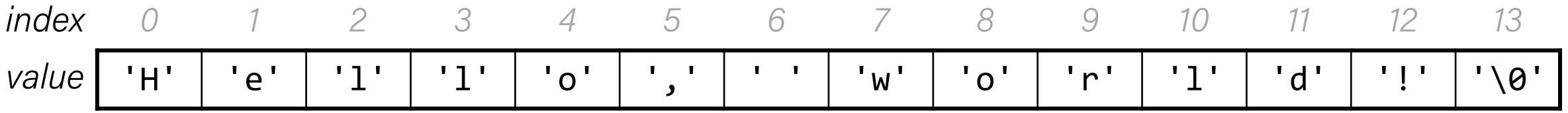
`diamond.c`

Lecture Plan

- String Diamond
- Searching in Strings
- Pointers

C Strings

C strings are arrays of characters ending with a **null-terminating character** '\0'.



String operations such as `strlen` use the null-terminating character to find the end of the string.

Side note: use `strlen` to get the length of a string. Don't use `sizeof`!

Common `string.h` Functions

Function	Description
`strlen(`***`str`***`)`	returns the # of chars in a C string (before null-terminating character).
`strcmp(`***`str1, str2`***`),` `strncmp(`***`str1, str2, n`***`)`	compares two strings; returns 0 if identical, <0 if ***`str1`*** comes before ***`str2`*** in alphabet, >0 if ***`str1`*** comes after ***`str2`*** in alphabet. ***`strncmp`*** stops comparing after at most ***`n`*** characters.
`strchr(`***`str, ch`***`)` `strrchr(`***`str, ch`***`)`	character search: returns a pointer to the first occurrence of ***`ch`*** in ***`str`***, or ***`NULL`*** if ***`ch`*** was not found in ***`str`***. `strrchr` find the last occurrence.
`strstr(`***`haystack, needle`***`)`	string search: returns a pointer to the start of the first occurrence of ***`needle`*** in ***`haystack`***, or ***`NULL`*** if ***`needle`*** was not found in ***`haystack`***.
`strcpy(`***`dst, src`***`),` `strncpy(`***`dst, src, n`***`)`	copies characters in ***`src`*** to ***`dst`***, including null-terminating character. Assumes enough space in ***`dst`***. Strings must not overlap. **`strncpy`** stops after at most ***`n`*** chars, and <u>does not</u> add null-terminating char.
`strcat(`***`dst, src`***`),` `strncat(`***`dst, src, n`***`)`	concatenate ***`src`*** onto the end of ***`dst`***. **`strncat`** stops concatenating after at most ***`n`*** characters. <u>Always</u> adds a null-terminating character.
`strspn(`***`str, accept`***`),` `strcspn(`***`str, reject`***`)`	**`strspn`** returns the length of the initial part of ***`str`*** which contains <u>only</u> characters in ***`accept`***. **`strcspn`** returns the length of the initial part of ***`str`*** which does <u>not</u> contain any characters in ***`reject`***.

Searching For Letters

`strchr` returns a pointer to the first occurrence of a character in a string, or NULL if the character is not in the string.

```
char daisy[6];
strcpy(daisy, "Daisy");
char *letterA = strchr(daisy, 'a');
printf("%s\n", daisy);              // Daisy
printf("%s\n", letterA);            // aisy
```

If there are multiple occurrences of the letter, **`strchr`** returns a pointer to the *first* one. Use **`strrchr`** to obtain a pointer to the *last* occurrence.

Searching For Strings

`strstr` returns a pointer to the first occurrence of the second string in the first, or NULL if it cannot be found.

```
char daisy[10];
strcpy(daisy, "Daisy Dog");
char *substr = strstr(daisy, "Dog");
printf("%s\n", daisy);              // Daisy Dog
printf("%s\n", substr);             // Dog
```

If there are multiple occurrences of the string, `strstr` returns a pointer to the *first* one.

String Spans

`strspn` returns the *length* of the initial part of the first string which contains only characters in the second string.

```
char daisy[10];
strcpy(daisy, "Daisy Dog");
int spanLength = strspn(daisy, "aDeoi");        // 3
```

“How many places can we go in the first string before I encounter a character not in the second string?”

String Spans

`strcspn` (c = "complement") returns the *length* of the initial part of the first string which contains only characters not in the second string.

```
char daisy[10];
strcpy(daisy, "Daisy Dog");
int spanLength = strcspn(daisy, "driso");      // 2
```

"How many places can we go in the first string before I encounter a character in the second string?"

C Strings As Parameters

When we pass a string as a parameter, it is passed as a **char *.** We can still operate on the string the same way as with a char[]. (*We'll see why today!)*.

```
int doSomething(char *str) {
     char secondChar = str[1];
     ...
}

// can also write this, but it is really a pointer
int doSomething(char str[]) { ...
```

Arrays of Strings

We can make an array of strings to group multiple strings together:

```
char *stringArray[5];   // space to store 5 char *s
```

We can also use the following shorthand to initialize a string array:

```
char *stringArray[] = {
     "Hello",
     "Hi",
     "Hey there"
};
```

Arrays of Strings

We can access each string using bracket syntax:

```
printf("%s\n", stringArray[0]);  // print out first string
```

When an array is passed as a parameter in C, C passes a *pointer to the first element of the array*. This is what **argv** is in **main**! This means we write the parameter type as:

```
void myFunction(char **stringArray) {

// equivalent to this, but it is really a double pointer
void myFunction(char *stringArray[]) {
```

Practice: Password Verification

Write a function **`verifyPassword`** that accepts a candidate password and certain password criteria and returns whether the password is valid.

```
bool verifyPassword(char *password, char *validChars,
char *badSubstrings[], int numBadSubstrings);
```

password is valid if it contains only letters in **validChars**, and does not contain any substrings in **badSubstrings**.

Practice: Password Verification

```
bool verifyPassword(char *password, char *validChars, char
*badSubstrings[], int numBadSubstrings);
```

Example:

```
char *invalidSubstrings[] = { "1234" };

bool valid1 = verifyPassword("1572", "0123456789",
          invalidSubstrings, 1);       // true
bool valid2 = verifyPassword("141234", "0123456789",
          invalidSubstrings, 1);       // false
```

Practice: Password Verification

`verify_password.c`

Lecture Plan

- String Diamond
- Searching in Strings
- Pointers

Pointers

- A *pointer* is a variable that stores a memory address.
- Because there is no pass-by-reference in C like in C++, pointers let us pass around the address of one instance of memory, instead of making many copies.
- One (8 byte) pointer can refer to any size memory location!
- Pointers are also essential for allocating memory on the heap, which we will cover later.
- Pointers also let us refer to memory generically, which we will cover later.

Memory

- Memory is a big array of bytes.
- Each byte has a unique numeric index that is commonly written in hexadecimal.
- A pointer stores one of these memory addresses.

Address	Value
	…
0x105	'\0'
0x104	'e'
0x103	'l'
0x102	'p'
0x101	'p'
0x100	'a'
	…

Memory

- Memory is a big array of bytes.
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Address	Value
	…
261	'\0'
260	'e'
259	'l'
258	'p'
257	'p'
256	'a'
	…

Looking Back at C++

How would we write a program with a function that takes in an **`int`** and modifies it? We might use *pass by reference*.

```
void myFunc(int& num) {
     num = 3;
}

int main(int argc, char *argv[]) {
     int x = 2;
     myFunc(x);
     printf("%d", x);   // 3!
     ...
}
```

Looking Ahead to C

- All parameters in C are “pass by value.” For efficiency purposes, arrays (and strings, by extension) passed in as parameters are converted to pointers.
- This means whenever we pass something as a parameter, we pass a copy.
- If we want to modify a parameter value in the function we call and have the changes persist afterwards, we can pass the location of the value instead of the value itself. This way we make a copy of the *address* instead of a copy of the *value*.

Pointers

```
int x = 2;


// Make a pointer that stores the address of x.
// (& means "address of")
int *xPtr = &x;


// Dereference the pointer to go to that address.
// (* means "dereference")
printf("%d", *xPtr);    // prints 2
```

Pointers

A pointer is a variable that stores a memory address.

```
void myFunc(int *intPtr) {
     *intPtr = 3;
}

int main(int argc, char *argv[]) {
     int x = 2;
     myFunc(&x);
     printf("%d", x);     // 3!
     ...
}
```

Pointers

A pointer is a variable that stores a memory address.

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void myFunc(int *intPtr) {
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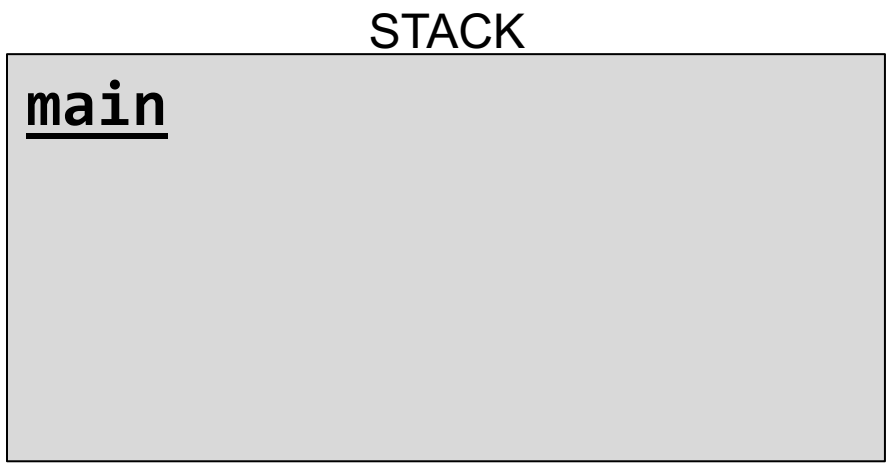
     int x = 2;
     myFunc(&x);
     printf("%d", x);     // 3!
     ...
}
```



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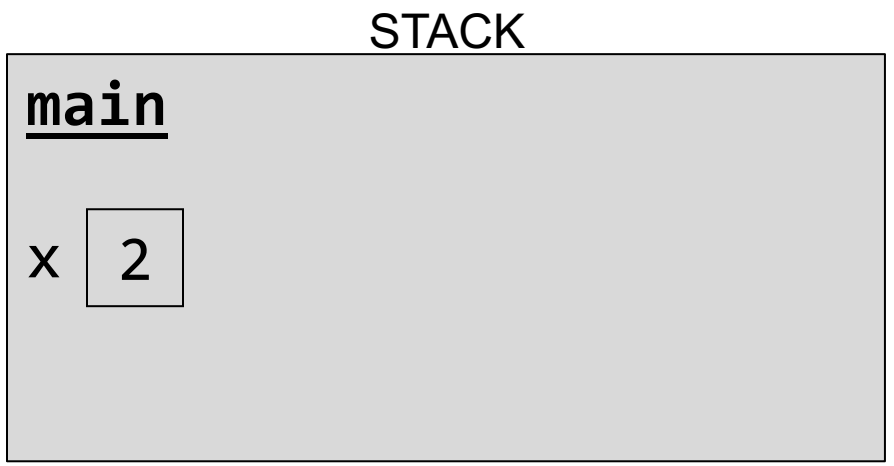

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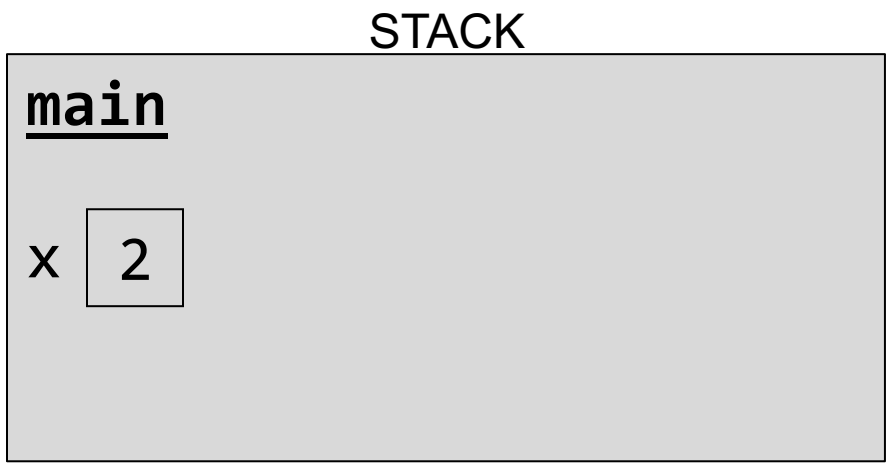

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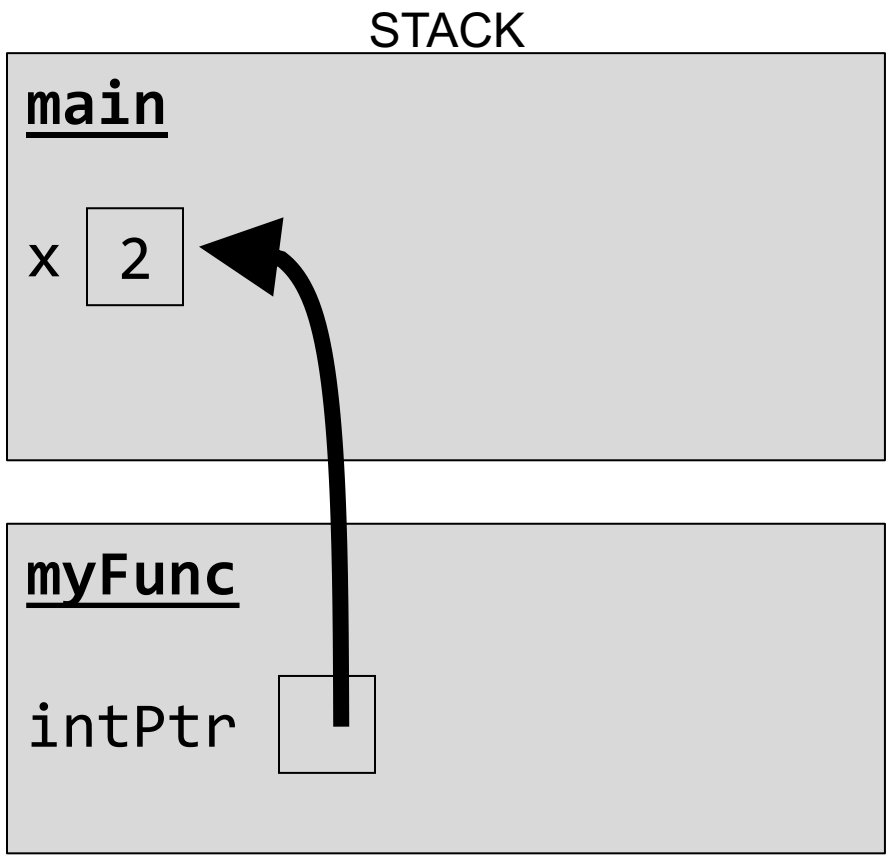

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     ...
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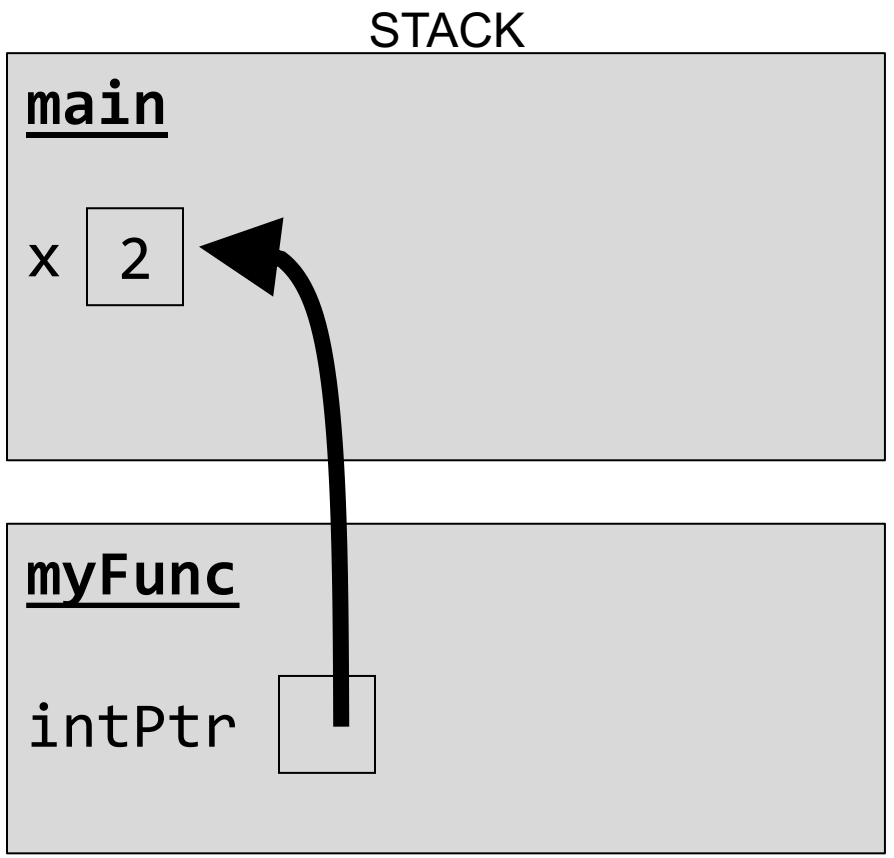

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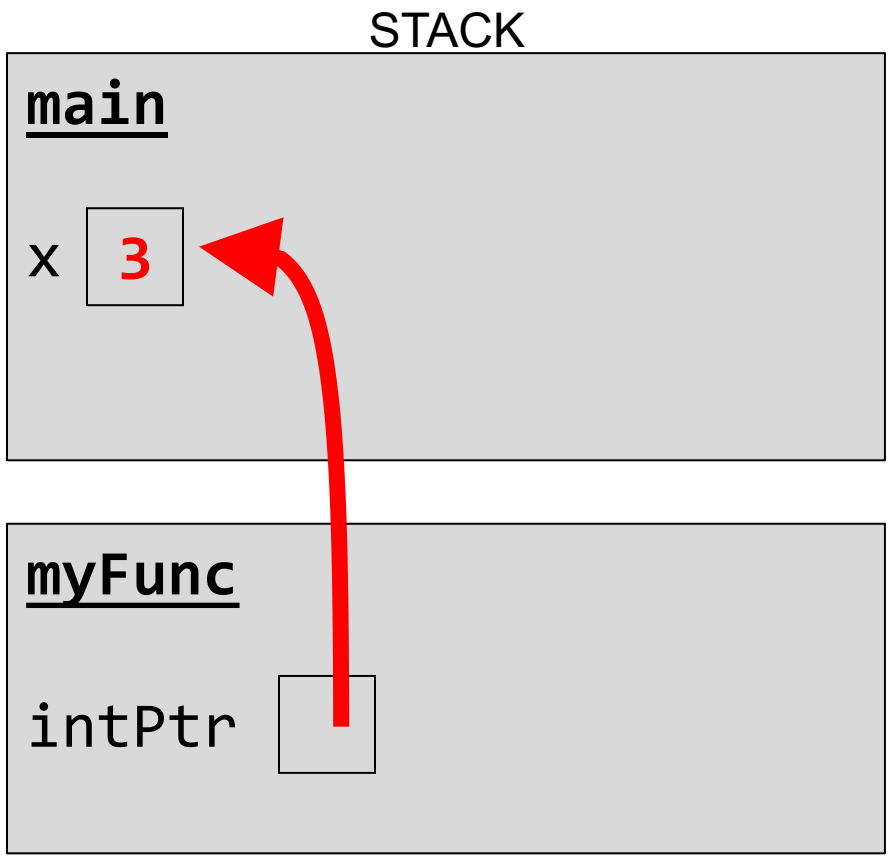

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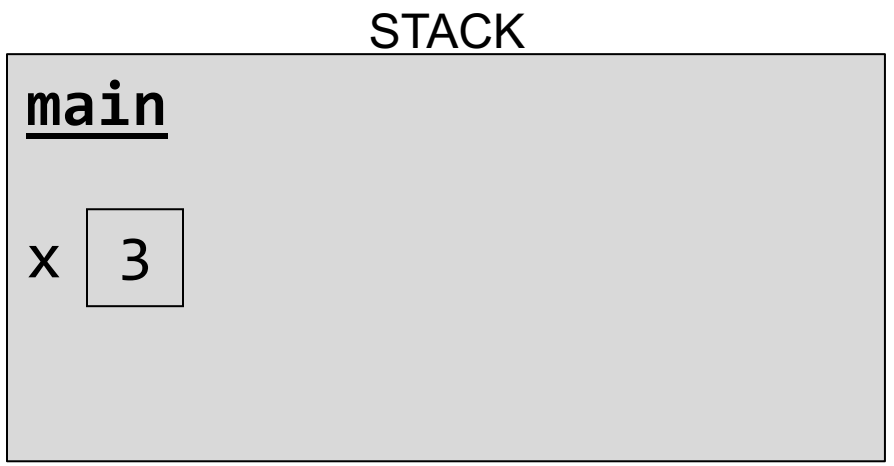

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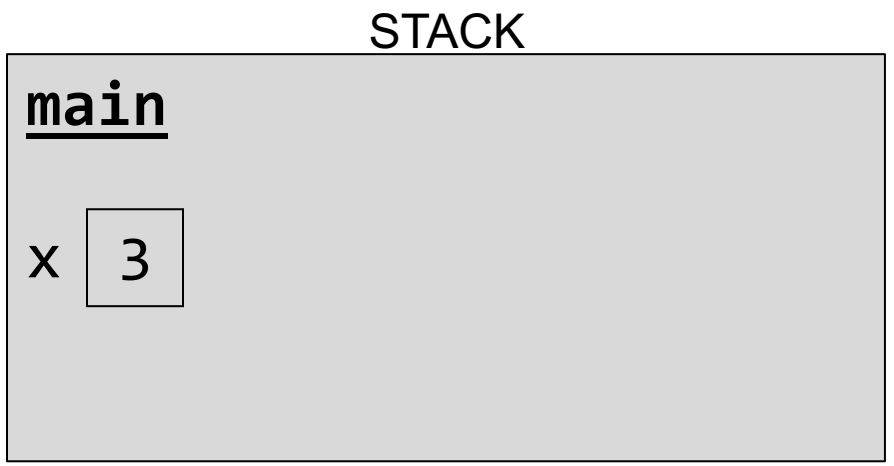

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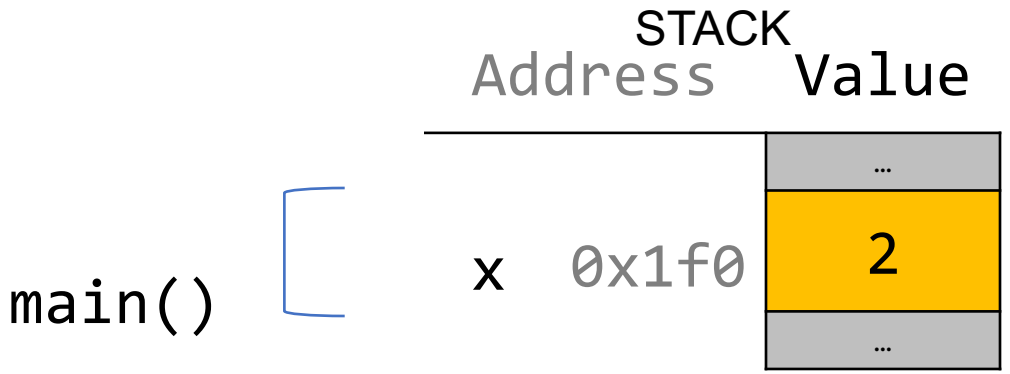

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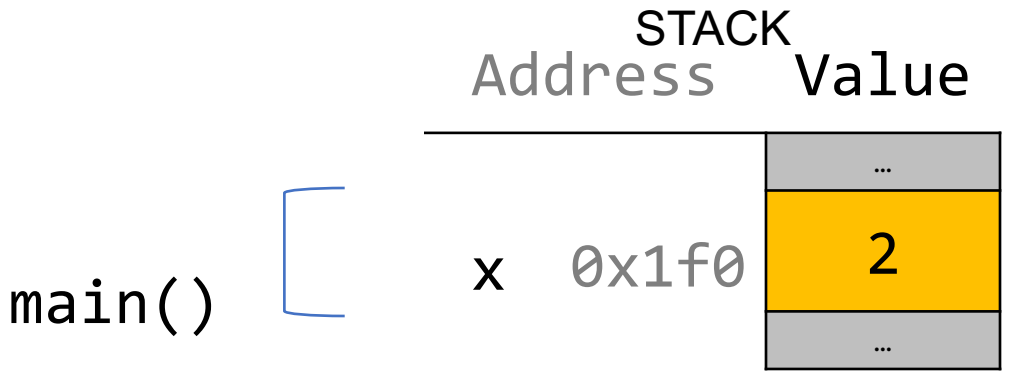

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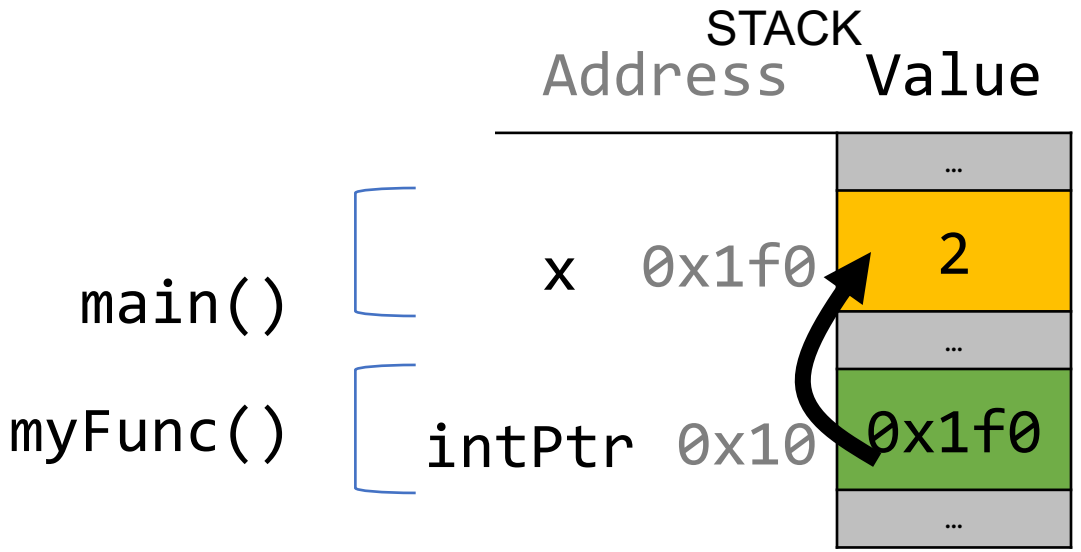

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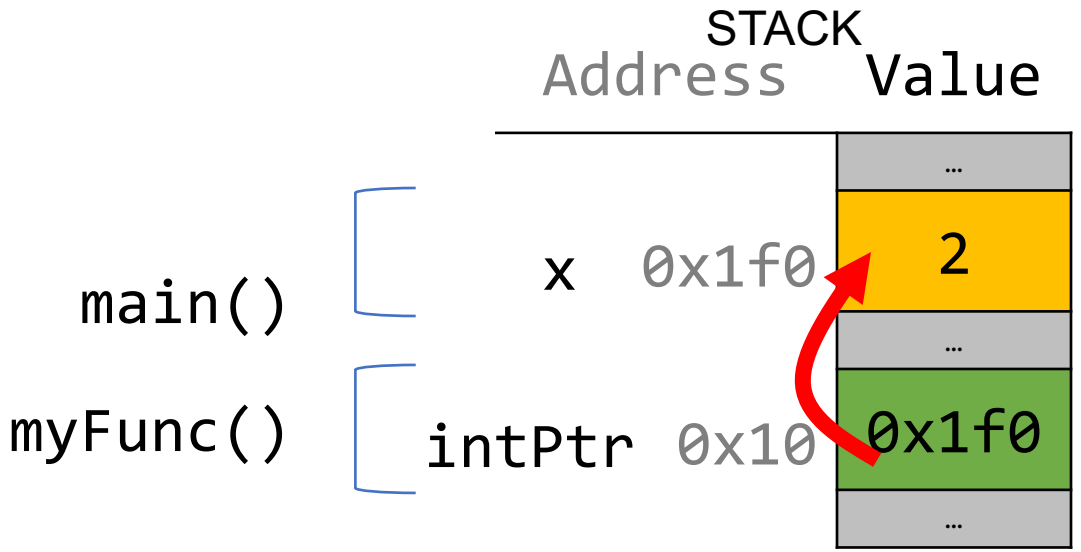

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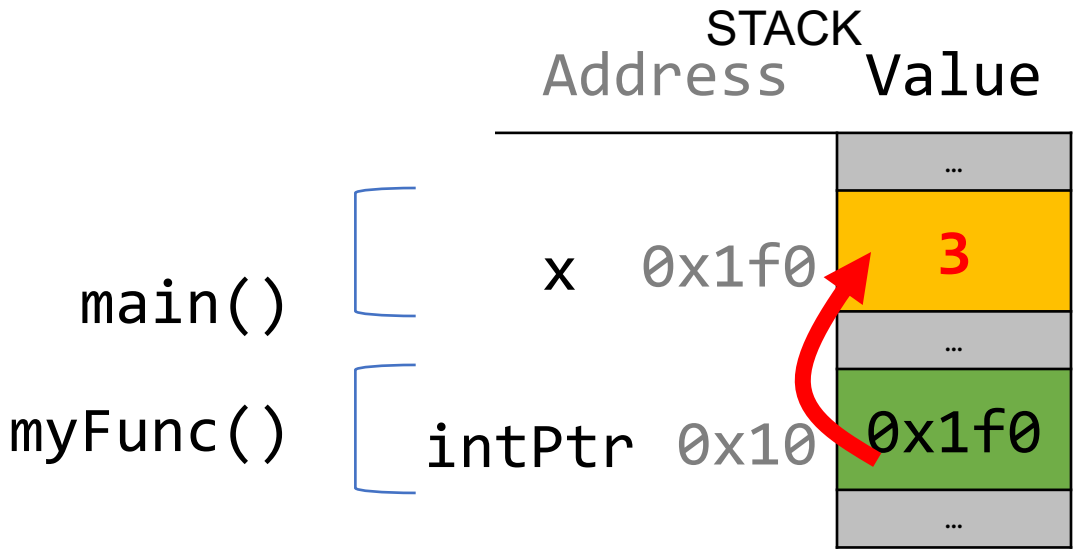

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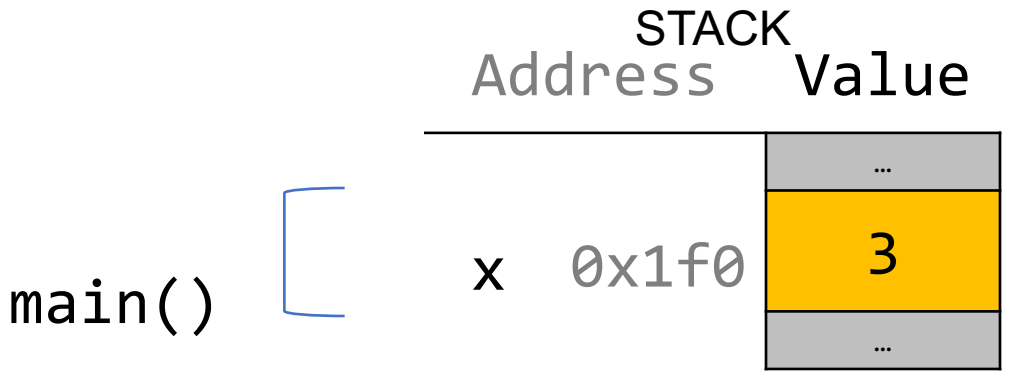

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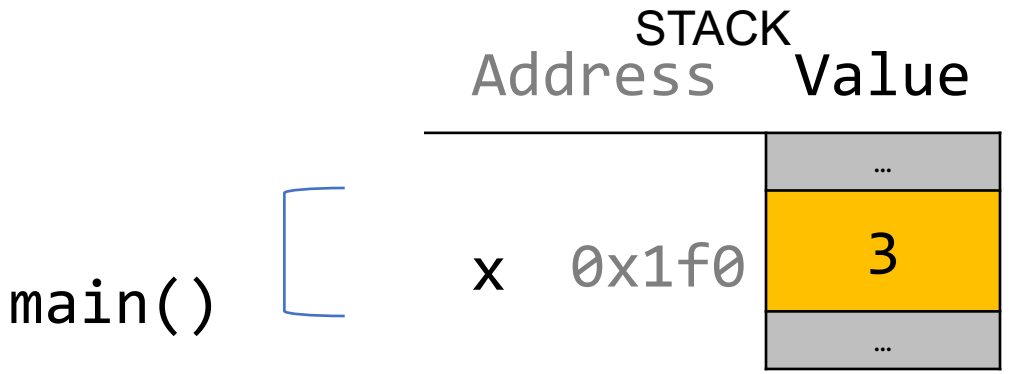


Pointers Summary

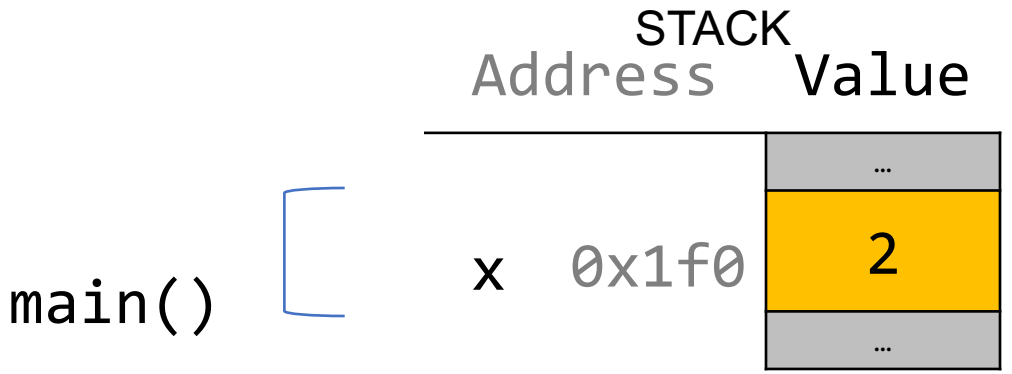
- If you are performing an operation with some input and do not care about any changes to the input, **pass the data type itself**. This makes a copy of the data.
- If you are modifying a specific instance of some value, **pass the location** of what you would like to modify. This makes a copy of the data's location.
- If a function takes an address (pointer) as a parameter, it can *go to* that address if it needs the actual value.

Pointers

Without pointers, we would make copies.

```
void myFunc(int val) {
     val = 3;
}

int main(int argc, char *argv[]) {
     int x = 2;
     myFunc(x);
     printf("%d", x);     // 2!
     ...
}
```



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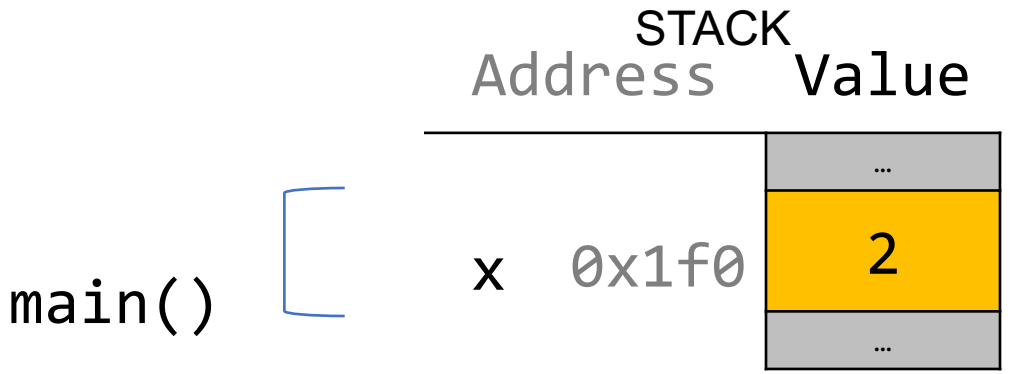

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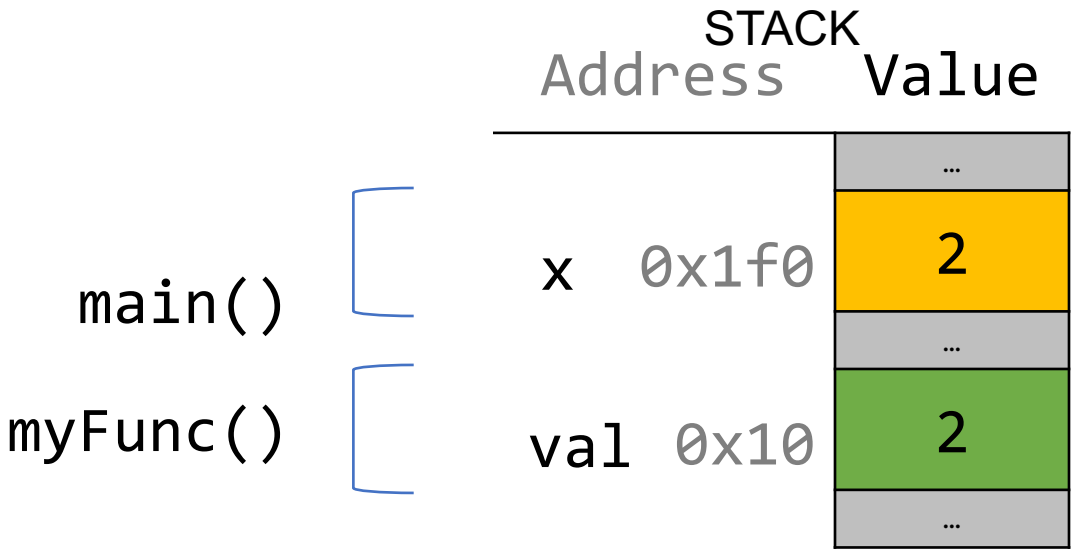

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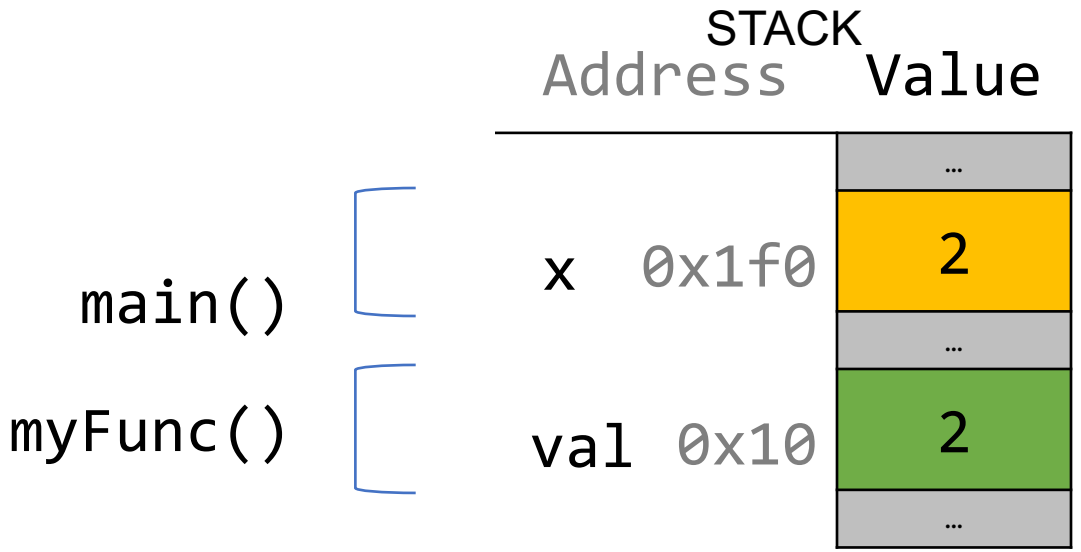

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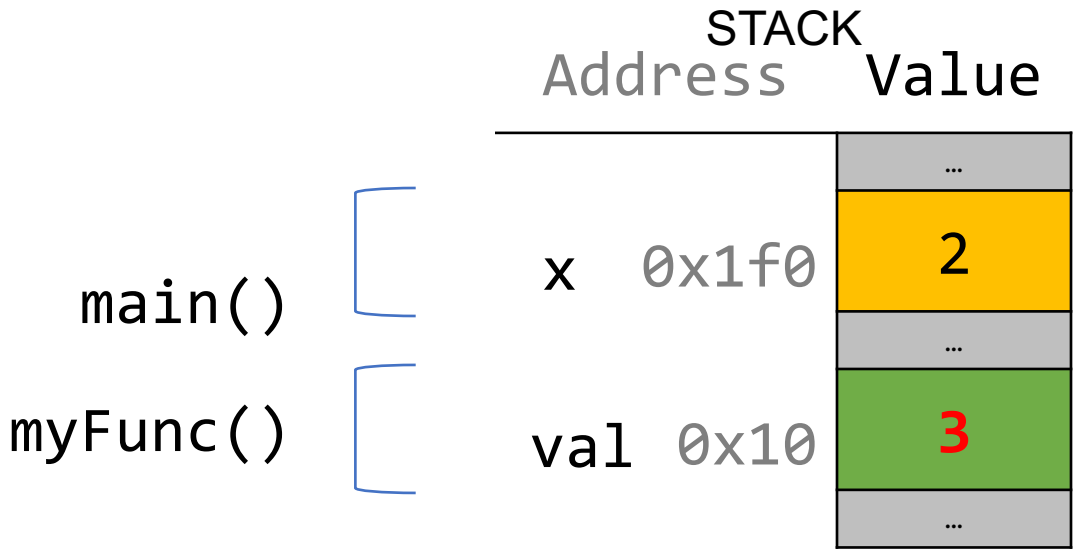

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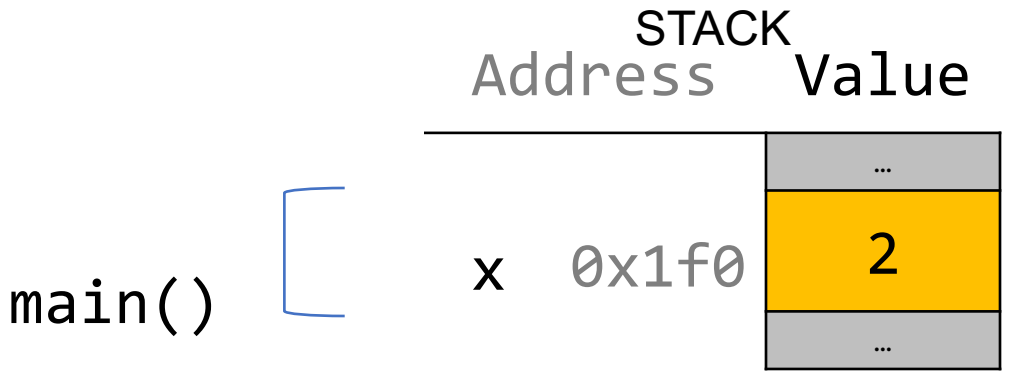

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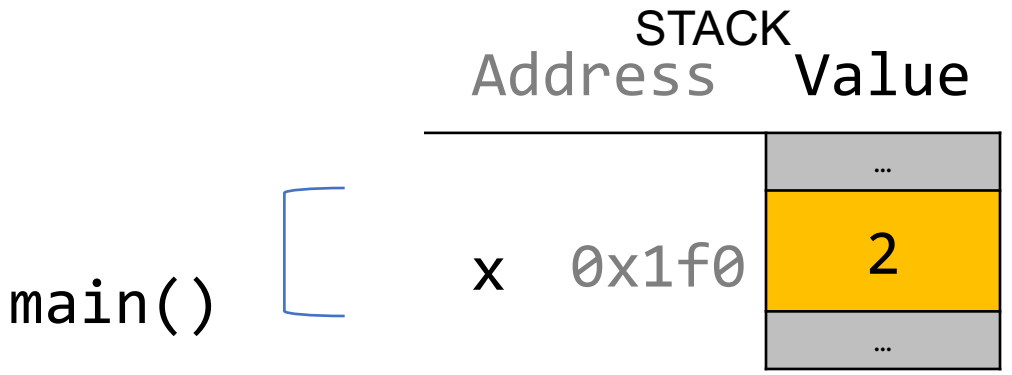

Recap

- String Diamond
- Searching in Strings
- Pointers

Next time: Strings in Memory