# CS107, Lecture 11

## C Generics – Void *

Reading: None 😍

Ed Discussion: https://edstem.org/us/courses/65949/discussion/5505467

Based on slides created by Cynthia Lee, Chris Gregg, Nick Troccoli, Lisa Yan, Jerry Cain and others.

# CS107 Topic 4: How can we use our knowledge of memory and data representation to write code that works with any data type?

# CS107 Topic 4

**How can we use our knowledge of memory and data representation to write code that works with any data type?**

Why is answering this question important?

- Writing code that works with any data type lets us write more generic, reusable code while understanding potential pitfalls (today and Friday)
- Allows us to learn how to pass functions as parameters, a core concept in many languages (Friday and next Monday)

**assign4:** implement your own version of the **ls** command, a function to generically find and insert elements into a sorted array, and a program using that function to sort the lines in a file like the **sort** command.

# Learning Goals

- Learn how to write C code that works with any data type.
- Learn about how to use void * and overcome its shortcomings.
- Learn about the potential harm from vulnerabilities, challenges to proper disclosure of vulnerabilities, and how we weigh competing interests.

# Generics

- We generally strive to write code that is as general-purpose as possible.
- Generic code minimizes code duplication so that optimizations and bug fixes can be managed in one place instead of many.
- Generics are used throughout C to sort arrays of any type, search arrays of any type, free arbitrary memory, and so forth.
- How can we write generic code in C?

# Swap

You’re asked to write a function that swaps two numbers.

```
void swap_int(int *a, int *b) {
    int temp = *a;
    *a = *b;
    *b = temp;
}

int main(int argc, char *argv[]) {
    int x = 2;
    int y = 5;
    swap_int(&x, &y);
    // want x = 5, y = 2
    printf("x = %d, y = %d\n", x, y);
    return 0;
}
```

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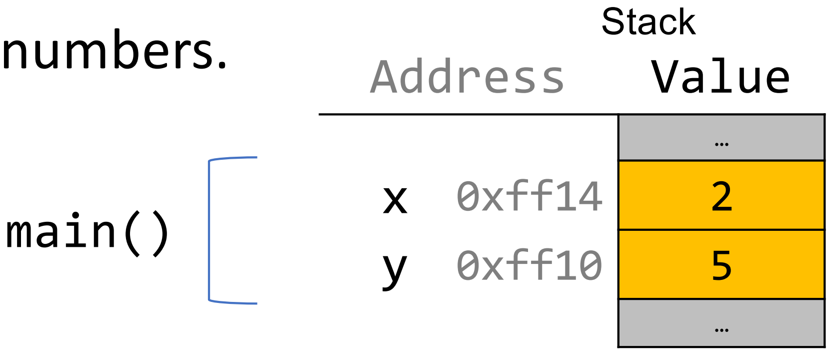
    int y = 5;
    swap_int(&x, &y);
    // want x = 5, y = 2
    printf("x = %d, y = %d\n", x, y);
    return 0;
}
```



Stack

| | | Address | Value |
|---|---|---|---|
| | | | … |
| main() | x | 0xff14 | 2 |
| | y | 0xff10 | 5 |
| | | | … |

# Swap

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```
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int main(int argc, char *argv[]) {
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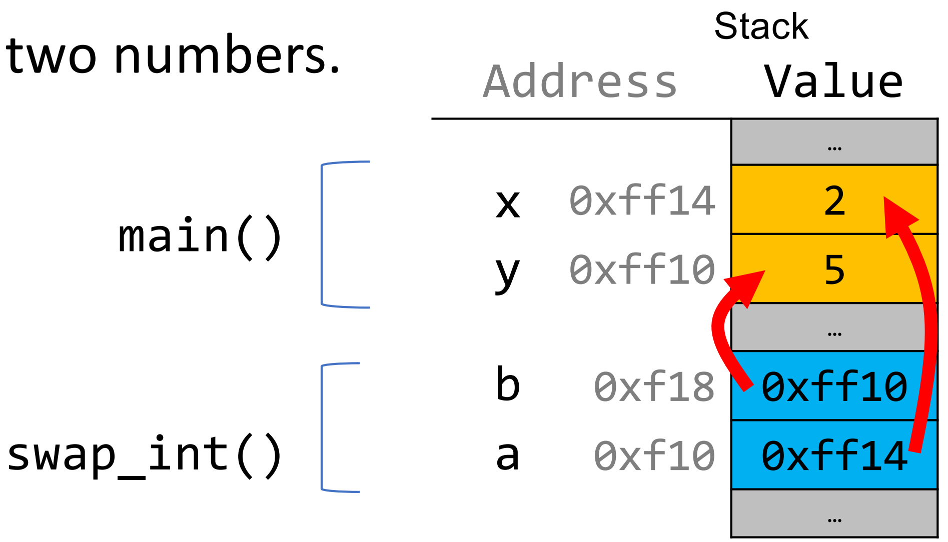
    int y = 5;
    swap_int(&x, &y);
    // want x = 5, y = 2
    printf("x = %d, y = %d\n", x, y);
    return 0;
}
```



Stack

| | | Address | Value |
|---|---|---|---|
| | | | … |
| main() | x | 0xff14 | 2 |
| | y | 0xff10 | 5 |
| | | | … |
| swap_int() | b | 0xf18 | 0xff10 |
| | a | 0xf10 | 0xff14 |
| | | | … |

# Swap

You’re asked to write a function that swaps two numbers.

```
void swap_int(int *a, int *b) {
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}

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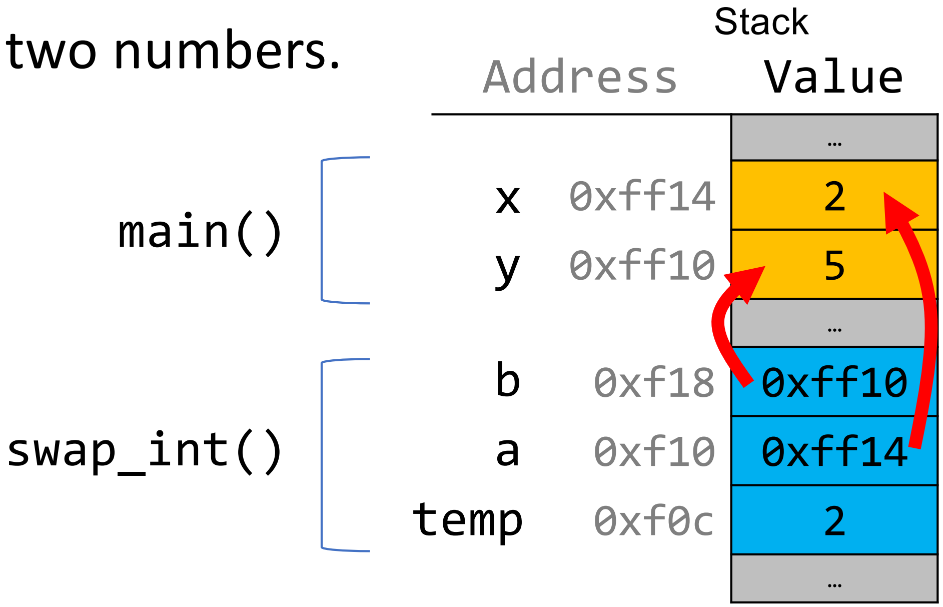
    swap_int(&x, &y);
    // want x = 5, y = 2
    printf("x = %d, y = %d\n", x, y);
    return 0;
}
```



Stack

| | | Address | Value |
|---|---|---|---|
| | | | … |
| main() | x | 0xff14 | 2 |
| | y | 0xff10 | 5 |
| | | | … |
| swap_int() | b | 0xf18 | 0xff10 |
| | a | 0xf10 | 0xff14 |
| | temp | 0xf0c | 2 |
| | | | … |

# Swap

You’re asked to write a function that swaps two numbers.

```
void swap_int(int *a, int *b) {
    int temp = *a;
    *a = *b;
    *b = temp;
}

int main(int argc, char *argv[]) {
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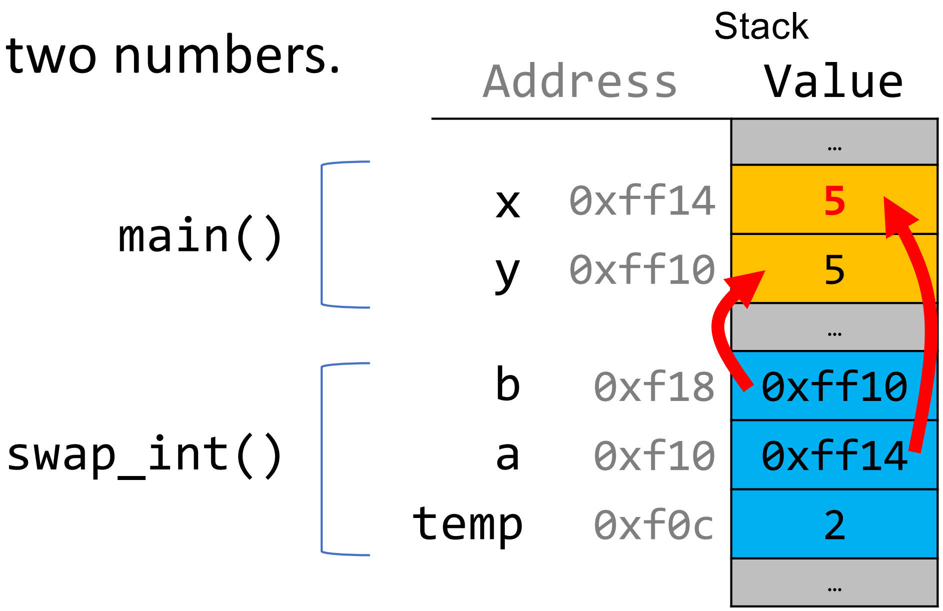
    int y = 5;
    swap_int(&x, &y);
    // want x = 5, y = 2
    printf("x = %d, y = %d\n", x, y);
    return 0;
}
```



Stack

| | | Address | Value |
|---|---|---|---|
| | | | … |
| main() | x | 0xff14 | 5 |
| | y | 0xff10 | 5 |
| | | | … |
| swap_int() | b | 0xf18 | 0xff10 |
| | a | 0xf10 | 0xff14 |
| | temp | 0xf0c | 2 |
| | | | … |

# Swap

You’re asked to write a function that swaps two numbers.

```
void swap_int(int *a, int *b) {
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}

int main(int argc, char *argv[]) {
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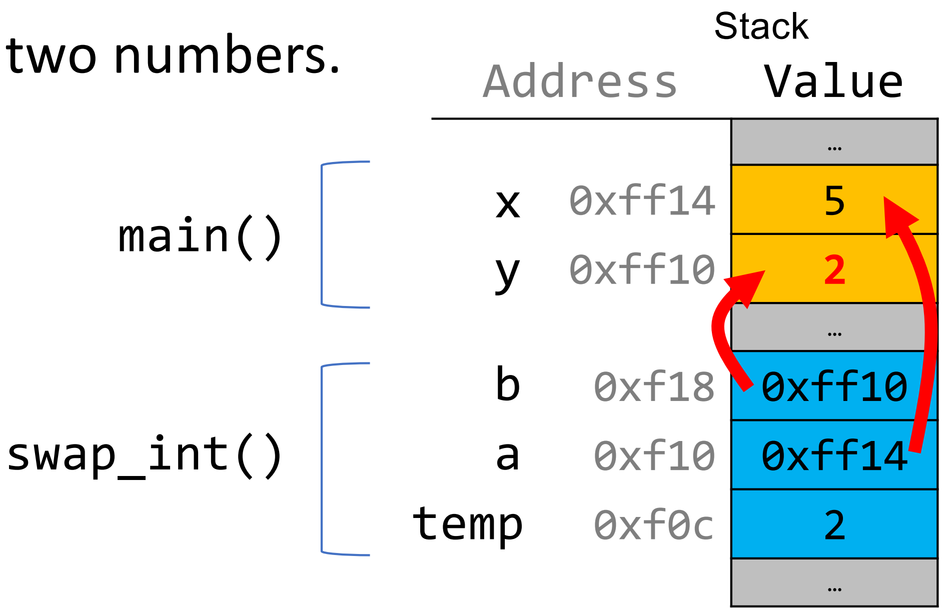
    int y = 5;
    swap_int(&x, &y);
    // want x = 5, y = 2
    printf("x = %d, y = %d\n", x, y);
    return 0;
}
```



Stack

| | | Address | Value |
|---|---|---|---|
| | | | … |
| main() | x | 0xff14 | 5 |
| | y | 0xff10 | 2 |
| | | | … |
| swap_int() | b | 0xf18 | 0xff10 |
| | a | 0xf10 | 0xff14 |
| | temp | 0xf0c | 2 |
| | | | … |

# Swap

You’re asked to write a function that swaps two numbers.

```
void swap_int(int *a, int *b) {
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    *a = *b;
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}

int main(int argc, char *argv[]) {
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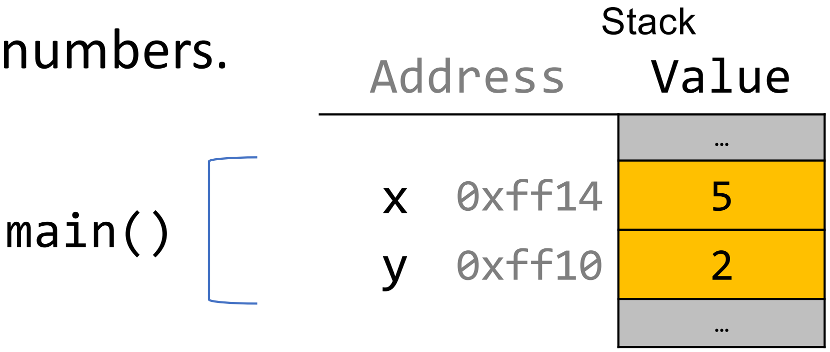
    int y = 5;
    swap_int(&x, &y);
    // want x = 5, y = 2
    printf("x = %d, y = %d\n", x, y);
    return 0;
}
```



Stack

| | Address | Value |
|---|---|---|
| | | … |
| main() x | 0xff14 | 5 |
| y | 0xff10 | 2 |
| | | … |

# Swap

You’re asked to write a function that swaps two numbers.

```
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}

int main(int argc, char *argv[]) {
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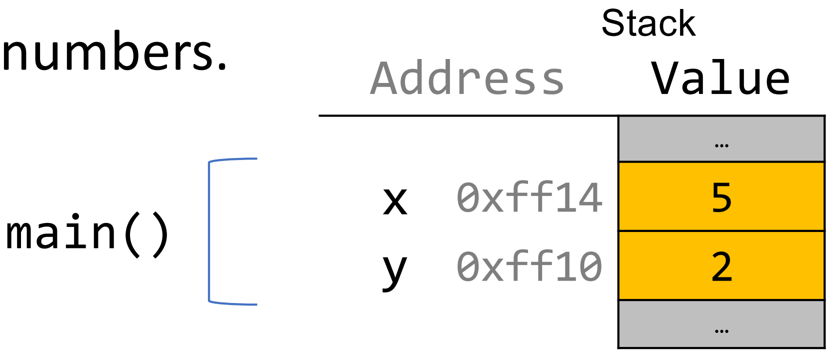
    int y = 5;
    swap_int(&x, &y);
    // want x = 5, y = 2
    printf("x = %d, y = %d\n", x, y);
    return 0;
}
```



Stack

| | | Address | Value |
|---|---|---|---|
| | | | … |
| main() | x | 0xff14 | 5 |
| | y | 0xff10 | 2 |
| | | | … |

# Swap

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    int y = 5;
    swap_int(&x, &y);
    // want x = 5, y = 2
    printf("x = %d, y = %d\n", x, y);
    return 0;
}
```
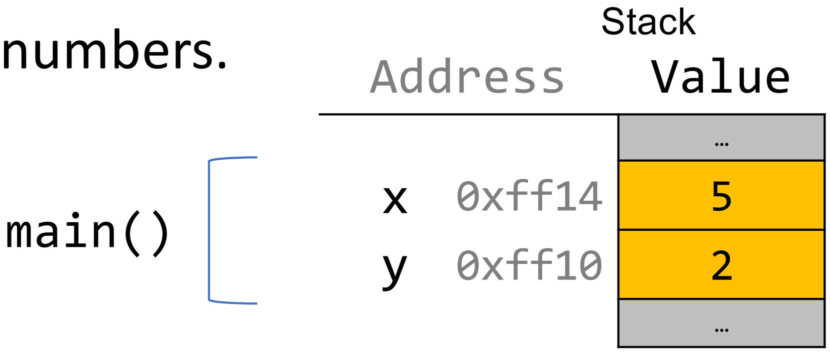



Stack

|  | Address | Value |
|---|---|---|
|  |  | … |
| x | 0xff14 | 5 |
| y | 0xff10 | 2 |
|  |  | … |

**"Oh, when I said ’numbers’ I meant shorts, not ints."**

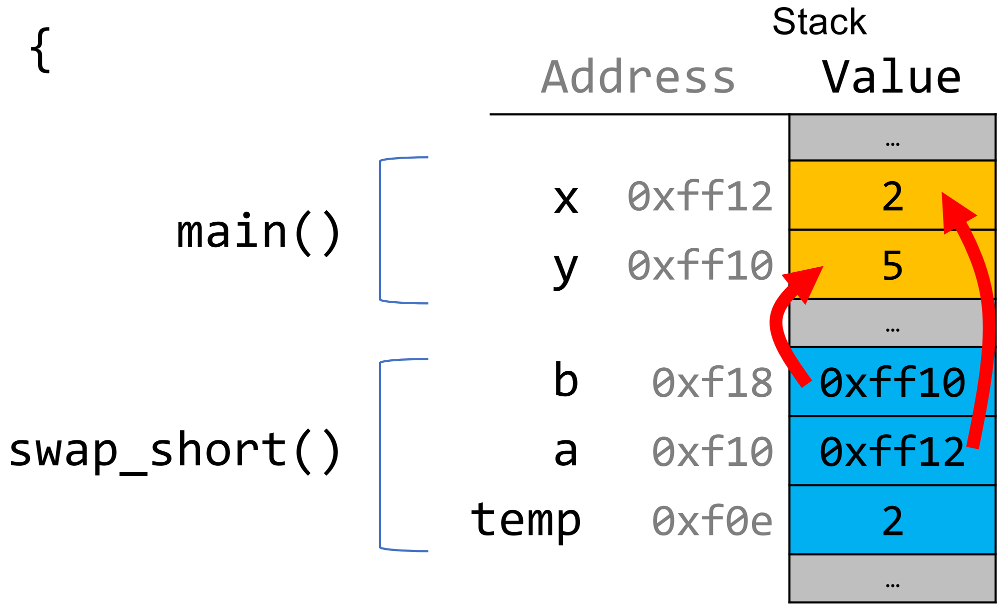
😑

# Swap

```c
void swap_short(short *a, short *b) {
    short temp = *a;
    *a = *b;
    *b = temp;
}

int main(int argc, char *argv[]) {
    short x = 2;
    short y = 5;
    swap_short(&x, &y);
    // want x = 5, y = 2
    printf("x = %d, y = %d\n", x, y);
    return 0;
}
```

# Swap

```
void swap_short(short *a, short *b) {
    short temp = *a;
    *a = *b;
    *b = temp;
}

int main(int argc, char *argv[]) {
    short x = 2;
    short y = 5;
    swap_short(&x, &y);
    // want x = 5, y = 2
    printf("x = %d, y = %d\n", x, y);
    return 0;
}
```



Stack

| | | Address | Value |
|---|---|---|---|
| | | | … |
| main() | x | 0xff12 | 2 |
| | y | 0xff10 | 5 |
| | | | … |
| swap_short() | b | 0xf18 | 0xff10 |
| | a | 0xf10 | 0xff12 |
| | temp | 0xf0e | 2 |
| | | | … |

"You know what, I messed up.  We’re going to use strings.  Could you write something to swap those?"

😤

# Swap

```c
void swap_string(char **a, char **b) {
    char *temp = *a;
    *a = *b;
    *b = temp;
}

int main(int argc, char *argv[]) {
    char *x = "2";
    char *y = "5";
    swap_string(&x, &y);
    // want x = 5, y = 2
    printf("x = %s, y = %s\n", x, y);
    return 0;
}
```

# Swap

```
void swap_string(char **a, char **b) {
    char *temp = *a;
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}

int main(int argc, char *argv[]) {
    char *x = "2";
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    swap_string(&x, &y);
    // want x = 5, y = 2
    printf("x = %s, y = %s\n", x, y);
    return 0;
}
```
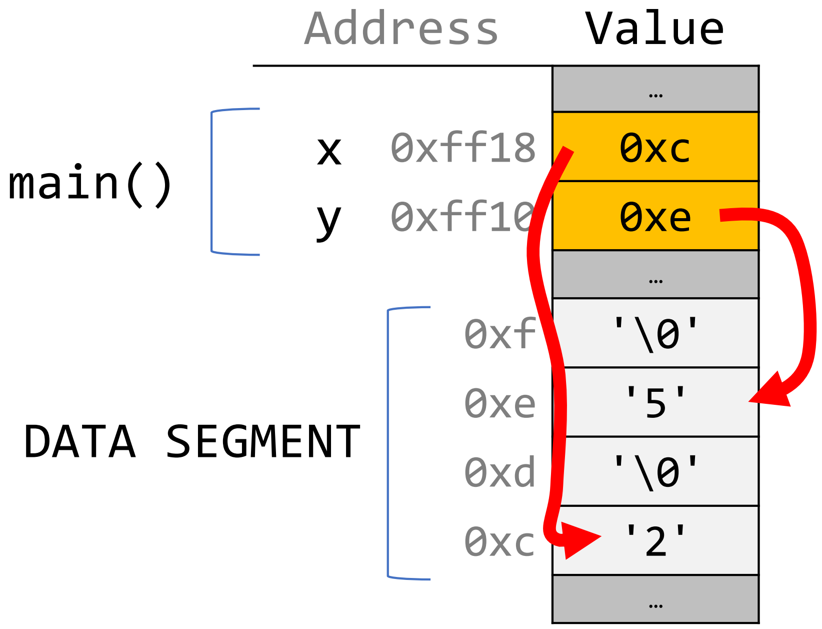
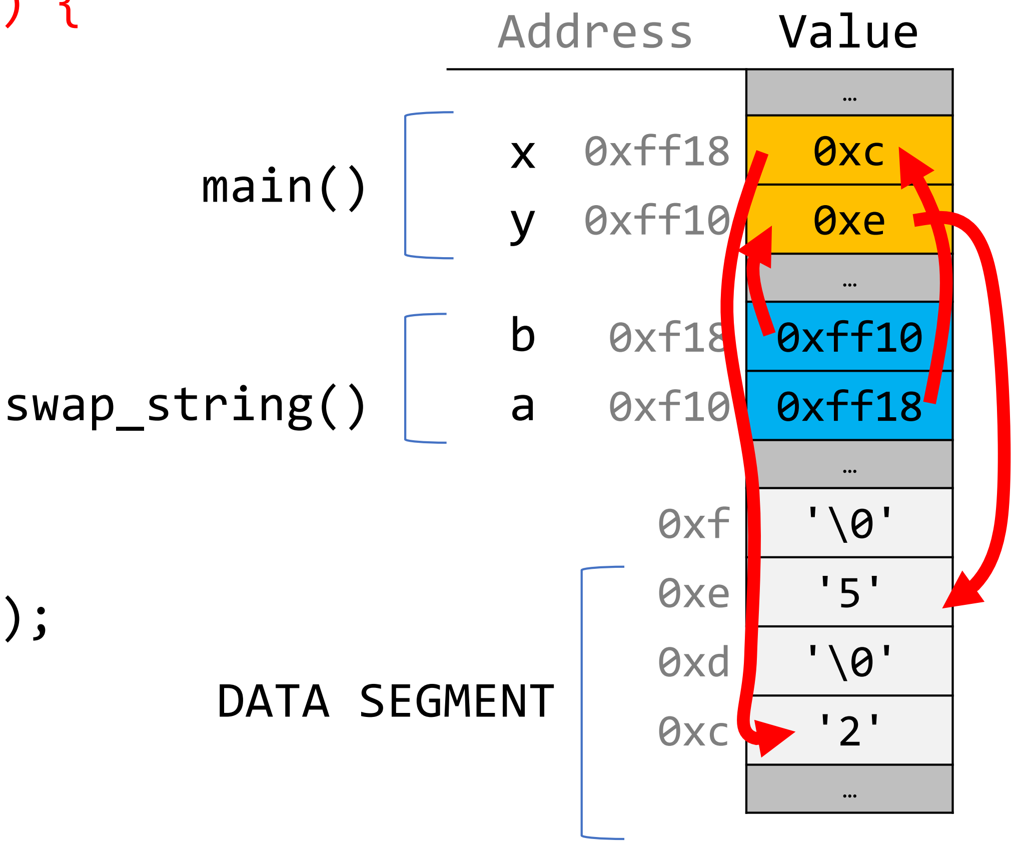



# Swap

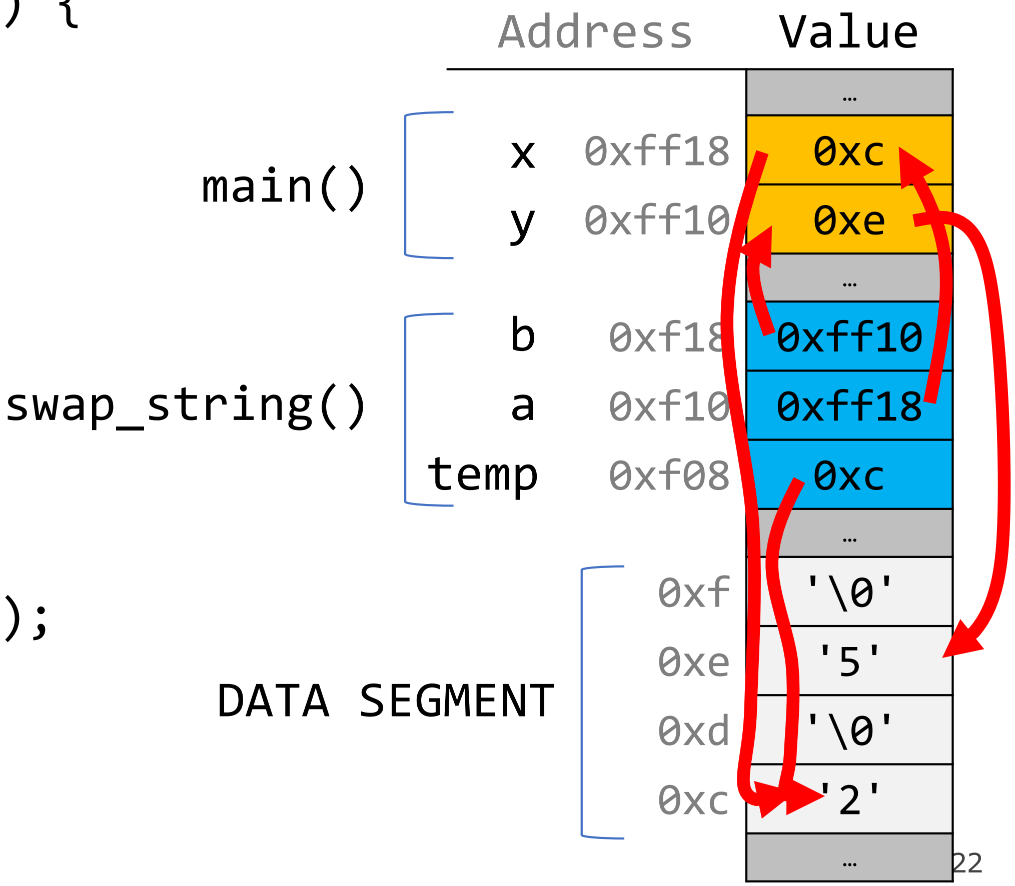
```
void swap_string(char **a, char **b) {
    char *temp = *a;
    *a = *b;
    *b = temp;
}

int main(int argc, char *argv[]) {
    char *x = "2";
    char *y = "5";
    swap_string(&x, &y);
    // want x = 5, y = 2
    printf("x = %s, y = %s\n", x, y);
    return 0;
}
```



|  |  | Address | Value |
|---|---|---|---|
|  |  |  | … |
| main() | x | 0xff18 | 0xc |
|  | y | 0xff10 | 0xe |
|  |  |  | … |
| swap_string() | b | 0xf18 | 0xff10 |
|  | a | 0xf10 | 0xff18 |
|  |  |  | … |
|  |  | 0xf | '\0' |
| DATA SEGMENT |  | 0xe | '5' |
|  |  | 0xd | '\0' |
|  |  | 0xc | '2' |
|  |  |  | … |

# Swap

```
void swap_string(char **a, char **b) {
    char *temp = *a;
    *a = *b;
    *b = temp;
}

int main(int argc, char *argv[]) {
    char *x = "2";
    char *y = "5";
    swap_string(&x, &y);
    // want x = 5, y = 2
    printf("x = %s, y = %s\n", x, y);
    return 0;
}
```



| | | Address | Value |
|---|---|---|---|
| | | | … |
| main() | x | 0xff18 | 0xc |
| | y | 0xff10 | 0xe |
| | | | … |
| swap_string() | b | 0xf18 | 0xff10 |
| | a | 0xf10 | 0xff18 |
| | temp | 0xf08 | 0xc |
| | | | … |
| DATA SEGMENT | | 0xf | '\0' |
| | | 0xe | '5' |
| | | 0xd | '\0' |
| | | 0xc | '2' |
| | | | … |

# Swap

```
void swap_string(char **a, char **b) {
    char *temp = *a;
    *a = *b;
    *b = temp;
}

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    char *x = "2";
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    swap_string(&x, &y);
    // want x = 5, y = 2
    printf("x = %s, y = %s\n", x, y);
    return 0;
}
```

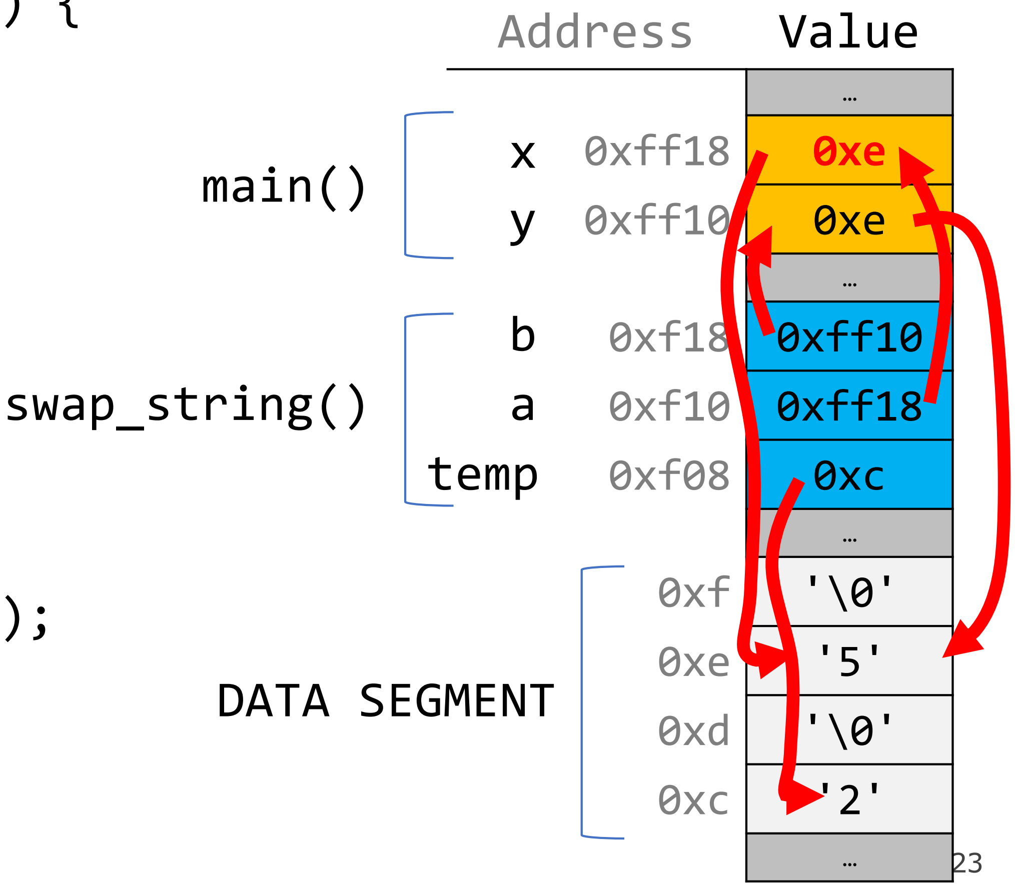

| | | Address | Value |
|---|---|---|---|
| | | | … |
| main() | x | 0xff18 | 0xe |
| | y | 0xff10 | 0xe |
| | | | … |
| swap_string() | b | 0xf18 | 0xff10 |
| | a | 0xf10 | 0xff18 |
| | temp | 0xf08 | 0xc |
| | | | … |
| DATA SEGMENT | | 0xf | '\0' |
| | | 0xe | '5' |
| | | 0xd | '\0' |
| | | 0xc | '2' |
| | | | … |

# Swap

```
void swap_string(char **a, char **b) {
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    char *y = "5";
    swap_string(&x, &y);
    // want x = 5, y = 2
    printf("x = %s, y = %s\n", x, y);
    return 0;
}
```
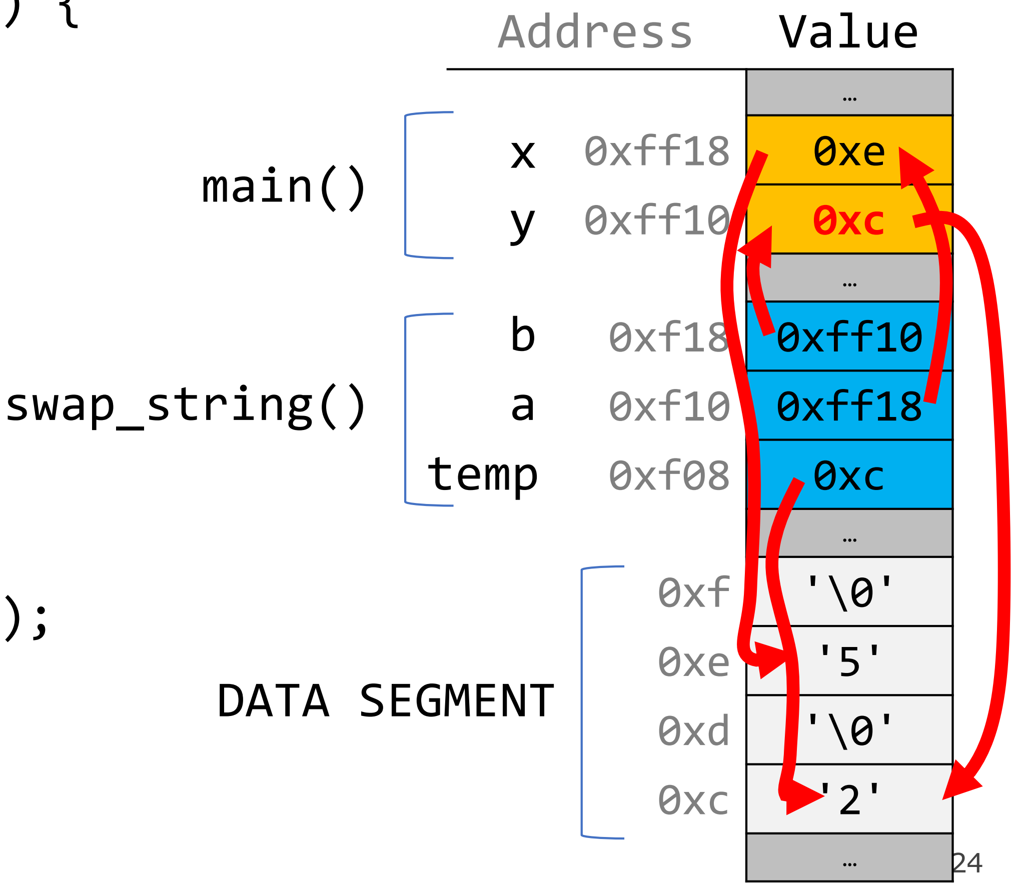
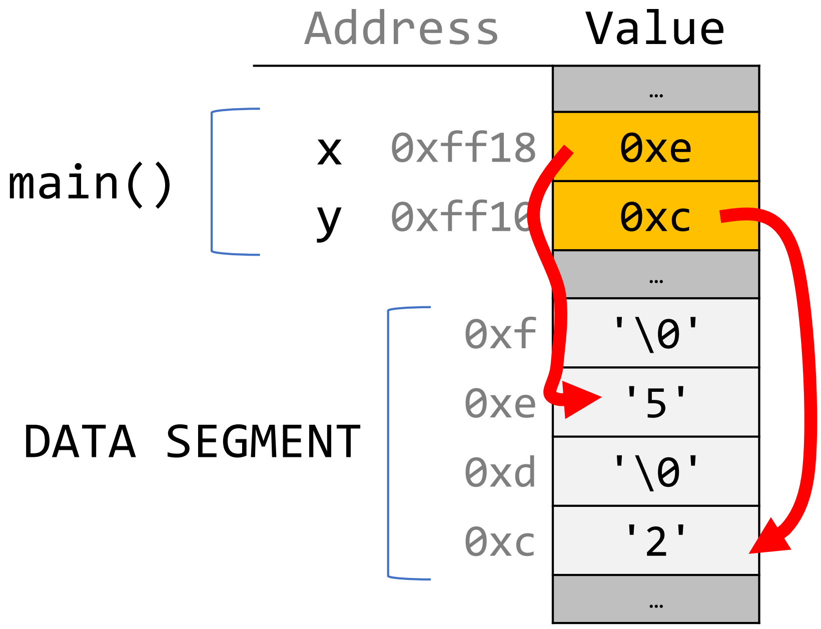



| | | Address | Value |
|---|---|---|---|
| | | | … |
| main() | x | 0xff18 | 0xe |
| | y | 0xff10 | 0xc |
| | | | … |
| swap_string() | b | 0xf18 | 0xff10 |
| | a | 0xf10 | 0xff18 |
| | temp | 0xf08 | 0xc |
| | | | … |
| DATA SEGMENT | | 0xf | '\0' |
| | | 0xe | '5' |
| | | 0xd | '\0' |
| | | 0xc | '2' |
| | | | … |

# Swap

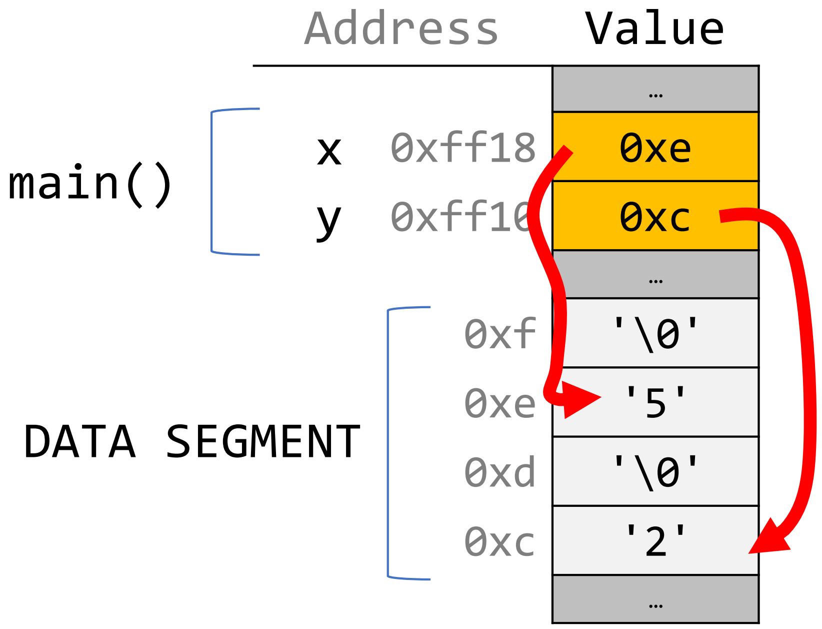
```
void swap_string(char **a, char **b) {
    char *temp = *a;
    *a = *b;
    *b = temp;
}

int main(int argc, char *argv[]) {
    char *x = "2";
    char *y = "5";
    swap_string(&x, &y);
    // want x = 5, y = 2
    printf("x = %s, y = %s\n", x, y);
    return 0;
}
```



| | | Address | Value |
|---|---|---|---|
| | | | … |
| main() | x | 0xff18 | 0xe |
| | y | 0xff10 | 0xc |
| | | | … |
| DATA SEGMENT | | 0xf | '\0' |
| | | 0xe | '5' |
| | | 0xd | '\0' |
| | | 0xc | '2' |
| | | | … |

# Swap

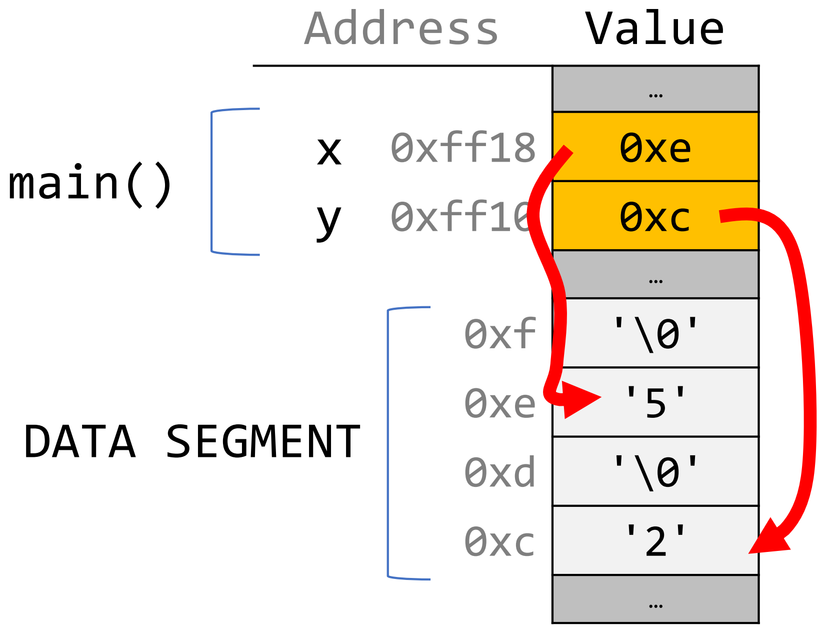
```
void swap_string(char **a, char **b) {
    char *temp = *a;
    *a = *b;
    *b = temp;
}

int main(int argc, char *argv[]) {
    char *x = "2";
    char *y = "5";
    swap_string(&x, &y);
    // want x = 5, y = 2
    printf("x = %s, y = %s\n", x, y);
    return 0;
}
```



|  |  | Address | Value |
|---|---|---|---|
|  |  |  | … |
| main() | x | 0xff18 | 0xe |
|  | y | 0xff10 | 0xc |
|  |  |  | … |
| DATA SEGMENT |  | 0xf | '\0' |
|  |  | 0xe | '5' |
|  |  | 0xd | '\0' |
|  |  | 0xc | '2' |
|  |  |  | … |

# Swap

```c
void swap_string(char **a, char **b) {
    char *temp = *a;
    *a = *b;
    *b = temp;
}

int main(int argc, char *argv[]) {
    char *x = "2";
    char *y = "5";
    swap_string(&x, &y);
    // want x = 5, y = 2
    printf("x = %s, y = %s\n", x, y);
    return 0;
}
```



|  |  | Address | Value |
|---|---|---|---|
|  |  |  | … |
| main() | x | 0xff18 | 0xe |
|  | y | 0xff10 | 0xc |
|  |  |  | … |
| DATA SEGMENT |  | 0xf | '\0' |
|  |  | 0xe | '5' |
|  |  | 0xd | '\0' |
|  |  | 0xc | '2' |
|  |  |  | … |

**"Awesome! Thanks. We also have 20 custom struct types. Could you write swap for those too?"**

🤬

# Generic Swap

What if we could write *one* function to swap two values of any single type?

```
void swap_int(int *a, int *b) { … }
void swap_float(float *a, float *b) { … }
void swap_size_t(size_t *a, size_t *b) { … }
void swap_double(double *a, double *b) { … }
void swap_string(char **a, char **b) { … }
void swap_mystruct(mystruct *a, mystruct *b) { … }
…
```

# Generic Swap

```
void swap_int(int *a, int *b) {
    int temp = *a;
    *a = *b;
    *b = temp;
}

void swap_short(short *a, short *b) {
    short temp = *a;
    *a = *b;
    *b = temp;
}

void swap_string(char **a, char **b) {
    char *temp = *a;
    *a = *b;
    *b = temp;
}
```

# Generic Swap

```
void swap_int(int *a, int *b) {
    int temp = *a;
    *a = *b;
    *b = temp;
}

void swap_short(short *a, short *b) {
    short temp = *a;
    *a = *b;
    *b = temp;
}

void swap_string(char **a, char **b) {
    char *temp = *a;
    *a = *b;
    *b = temp;
}
```

All three of these:

- Take pointers to values to that should be exchanged
- Create temporary storage to store one of the values
- Move data addressed by **b** into the space addressed by **a**
- Move copy of temporary into spaces addressed by **b**

# Generic Swap

```
void swap(pointer to data1, pointer to data2) {
    store a copy of data1 in temporary storage
    copy data2 to location of data1
    copy data in temporary storage to location of data2
}
```

# Generic Swap

```
void swap(pointer to data1, pointer to data2) {
    store a copy of data1 in temporary storage
    copy data2 to location of data1
    copy data in temporary storage to location of data2
}
```

| | |
|---|---|
| `int temp = *data1ptr;` | 4 bytes |
| `short temp = *data1ptr;` | 2 bytes |
| `char *temp = *data1ptr;` | 8 bytes |

**Problem:** each type may need a different size temp!

# Generic Swap

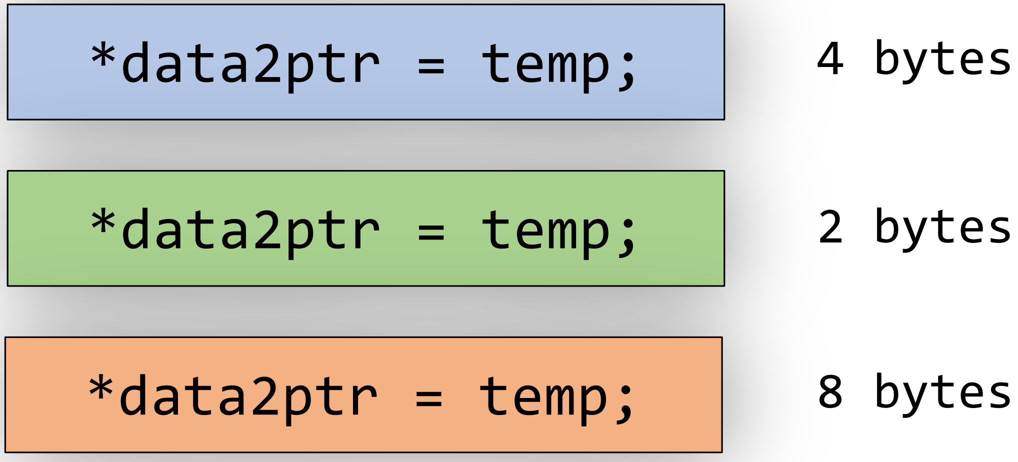
```
void swap(pointer to data1, pointer to data2) {
    store a copy of data1 in temporary storage
    copy data2 to location of data1
    copy data in temporary storage to location of data2
}
```

```
*data1Ptr = *data2ptr;      4 bytes

*data1Ptr = *data2ptr;      2 bytes

*data1Ptr = *data2ptr;      8 bytes
```

**Problem:** each type needs to copy a different amount of data!

# Generic Swap

```
void swap(pointer to data1, pointer to data2) {
    store a copy of data1 in temporary storage
    copy data2 to location of data1
    copy data in temporary storage to location of data2
}
```



```
*data2ptr = temp;      4 bytes
*data2ptr = temp;      2 bytes
*data2ptr = temp;      8 bytes
```

**Problem:** each type needs to copy a different amount of data!

**C knows the size of `temp`, and knows how many bytes to replicate, because of the variable types.**

**Is there a way to make a version that doesn’t care about the variable types?**

# Generic Swap

```
void swap(pointer to data1, pointer to data2) {
    store a copy of data1 in temporary storage
    copy data2 to location of data1
    copy data in temporary storage to location of data2
}
```

# Generic Swap

```
void swap(pointer to data1, pointer to data2) {
    store a copy of data1 in temporary storage
    copy data2 to location of data1
    copy data in temporary storage to location of data2
}
```

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr) {
    store a copy of data1 in temporary storage
    copy data2 to location of data1
    copy data in temporary storage to location of data2
}
```

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr) {
    // store a copy of data1 in temporary storage
    // copy data2 to location of data1
    // copy data in temporary storage to location of data2
}
```

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr) {
    // store a copy of data1 in temporary storage
    // copy data2 to location of data1
    // copy data in temporary storage to location of data2
}
```

If we don’t know the data type, we don’t know how many bytes it is.  Let’s take that as another parameter.

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    // store a copy of data1 in temporary storage
    // copy data2 to location of data1
    // copy data in temporary storage to location of data2
}
```

If we don’t know the data type, we don’t know how many bytes it is.  Let’s take that as another parameter.

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    // store a copy of data1 in temporary storage
    // copy data2 to location of data1
    // copy data in temporary storage to location of data2
}
```

Let’s start by making space to store the temporary value.  How can we make **nbytes** of temp space?

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    void temp; ???
    // store a copy of data1 in temporary storage
    // copy data2 to location of data1
    // copy data in temporary storage to location of data2
}
```

Let’s start by making space to store the temporary value. How can we make **nbytes** of temp space?

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    // copy data2 to location of data1
    // copy data in temporary storage to location of data2
}
```

**temp** is **nbytes** of memory, since each **char** is 1 byte!

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    // copy data2 to location of data1
    // copy data in temporary storage to location of data2
}
```

Now, how can we copy in what **data1ptr** points to into **temp**?

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    temp = *data1ptr; ???
    // copy data2 to location of data1
    // copy data in temporary storage to location of data2
}
```

Now, how can we copy in what **data1ptr** points to into **temp**?

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    temp = *data1ptr; ???
    // copy data2 to location of data1
    // copy data in temporary storage to location of data2
}
```

We can’t dereference a **void *** (or set an array equal to something). C doesn’t know what it points to! Therefore, it doesn’t know how many bytes there it should be looking at.

# memcpy

**memcpy** is a function that copies a specified amount of bytes at one address to another address.

```
void *memcpy(void *dest, const void *src, size_t n);
```

It copies the next n bytes that src points to to the location contained in dest. (It also returns **dest**). It does not support regions of memory that overlap.

memcpy must take **pointers** to the bytes to work with to know where they live and where they should be copied to.

```
int x = 5;
int y = 4;
memcpy(&x, &y, sizeof(x));  // like x = y
```

# memmove

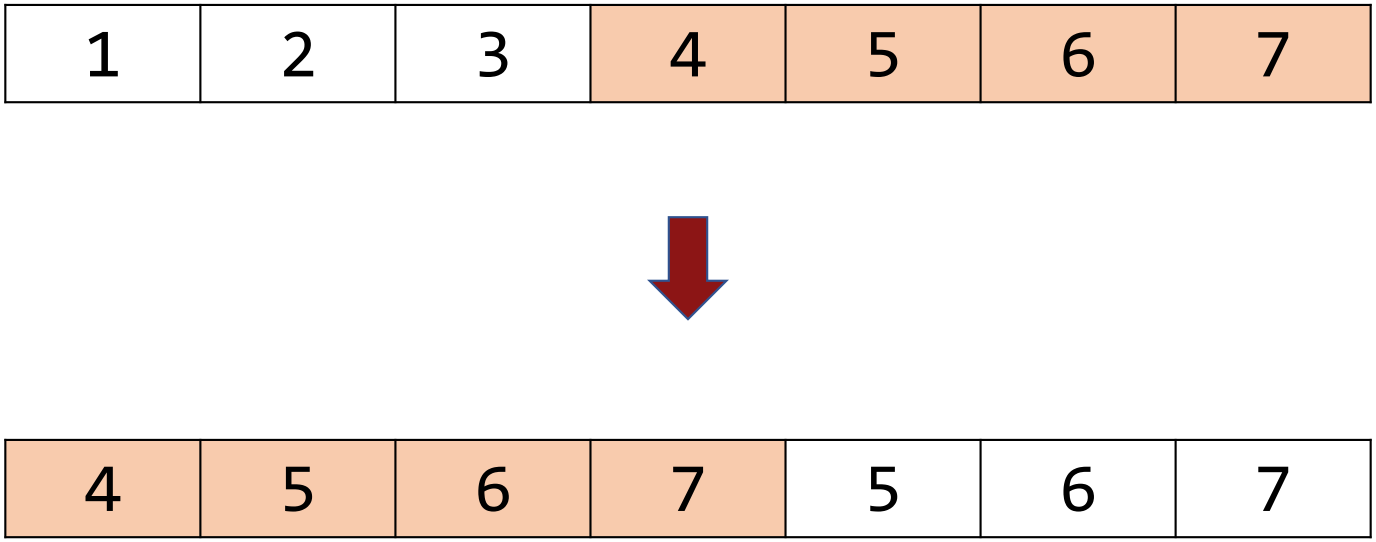
**memmove** is the same as **memcpy**, except it handles overlapping memory figures.

```
void *memmove(void *dest, const void *src, size_t n);
```

It copies the next n bytes that src points to to the location contained in dest.  (It also returns **dest**).

# memmove

When might **memmove** be useful?



| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | 5 | 6 | 7 | 5 | 6 | 7 |

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    temp = *data1ptr; ???
    // copy data2 to location of data1
    // copy data in temporary storage to location of data2
}
```

We can’t dereference a **void ***. C doesn’t know what it points to! Therefore, it doesn’t know how many bytes there it should be looking at.

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    temp = *data1ptr; ???
    // copy data2 to location of data1
    // copy data in temporary storage to location of data2
}
```

How can **memcpy** or **memmove** help us here? (Assume data to be swapped is not overlapping).

```
void *memcpy(void *dest, const void *src, size_t n);

void *memmove(void *dest, const void *src, size_t n);
```

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    memcpy(temp, data1ptr, nbytes);
    // copy data2 to location of data1
    // copy data in temporary storage to location of data2
}
```

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    memcpy(temp, data1ptr, nbytes);
    // copy data2 to location of data1
    // copy data in temporary storage to location of data2
}
```

We can copy the bytes ourselves into temp! This is equivalent to **temp = *data1ptr** in non-generic versions, but this works for *any* type of *any* size.

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    memcpy(temp, data1ptr, nbytes);
    // copy data2 to location of data1
    // copy data in temporary storage to location of data2
}
```

How can we copy data2 to the location of data1?

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    memcpy(temp, data1ptr, nbytes);
    // copy data2 to location of data1
    *data1ptr = *data2ptr; ???
    // copy data in temporary storage to location of data2
}
```

How can we copy data2 to the location of data1?

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    memcpy(temp, data1ptr, nbytes);
    // copy data2 to location of data1
    memcpy(data1ptr, data2ptr, nbytes);
    // copy data in temporary storage to location of data2
}
```

How can we copy data2 to the location of data1?

**memcpy**!

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    memcpy(temp, data1ptr, nbytes);
    // copy data2 to location of data1
    memcpy(data1ptr, data2ptr, nbytes);
    // copy data in temporary storage to location of data2
}
```

How can we copy temp’s data to the location of data2?

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    memcpy(temp, data1ptr, nbytes);
    // copy data2 to location of data1
    memcpy(data1ptr, data2ptr, nbytes);
    // copy data in temporary storage to location of data2
    memcpy(data2ptr, temp, nbytes);
}
```

How can we copy temp’s data to the location of data2? **memcpy**!

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    memcpy(temp, data1ptr, nbytes);
    // copy data2 to location of data1
    memcpy(data1ptr, data2ptr, nbytes);
    // copy data in temporary storage to location of data2
    memcpy(data2ptr, temp, nbytes);
}
```

```
int x = 2;
int y = 5;
swap(&x, &y, sizeof(x));
```

# Generic Swap

```c
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    memcpy(temp, data1ptr, nbytes);
    // copy data2 to location of data1
    memcpy(data1ptr, data2ptr, nbytes);
    // copy data in temporary storage to location of data2
    memcpy(data2ptr, temp, nbytes);
}
```

```c
short x = 2;
short y = 5;
swap(&x, &y, sizeof(x));
```

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    memcpy(temp, data1ptr, nbytes);
    // copy data2 to location of data1
    memcpy(data1ptr, data2ptr, nbytes);
    // copy data in temporary storage to location of data2
    memcpy(data2ptr, temp, nbytes);
}
```

```
char *x = "2";
char *y = "5";
swap(&x, &y, sizeof(x));
```

# Generic Swap

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    // store a copy of data1 in temporary storage
    memcpy(temp, data1ptr, nbytes);
    // copy data2 to location of data1
    memcpy(data1ptr, data2ptr, nbytes);
    // copy data in temporary storage to location of data2
    memcpy(data2ptr, temp, nbytes);
}
```

```
mystruct x = {…};
mystruct y = {…};
swap(&x, &y, sizeof(x));
```

# C Generics

- We can use **void *** and **memcpy** to manipulate raw memory.
- If we know where the data is and how big it is, we can manipulate it!

```
void swap(void *data1ptr, void *data2ptr, size_t nbytes) {
    char temp[nbytes];
    memcpy(temp, data1ptr, nbytes);
    memcpy(data1ptr, data2ptr, nbytes);
    memcpy(data2ptr, temp, nbytes);
}
```

# void *, memcpy, memmove

From a design standpoint, why does **memcpy** take **void ***s as parameters?

```
int x = 2;
int y = 3;
memcpy(&x, &y, sizeof(x));  // copy 3 into x

// why not this?
memcpy(x, y);
```

1. The first parameter must be a pointer so **memcpy** knows where to copy to.
2. The second parameter *could* be a non-pointer. But then there must be a version of **memcpy** for every possible type we would like to copy!

**memcpy_i(void *, int); memcpy_c(void *, char); memcpy_d(void *, double);**

# Void * Pitfalls

- **void ***s are powerful, but dangerous - C can’t do any type checking!
- With **int**s, for example, C would never let you swap *half* of an int.  With **void *s**, this can happen! (*How?  Let’s find out!)*

# Demo: Void *s Gone Wrong

`swap.c`

# Void *Pitfalls

- void * has more room for error because it manipulates arbitrary bytes without knowing what they represent.  This can result in some strange memory Frankensteins!

http://i.ytimg.com/vi/10gPoYjq3EA/hqdefault.jpg