C Advanced Topics

Structures, Unions, Bit Fields, Make and Makefiles

Programming with C

SoftUni Team

Technical Trainers

Software University

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Enumerations

- Enums are a set of constants

  - Represented as integers in memory (starting from 0 by default)

```c
#include <stdio.h>
enum days { MONDAY, TUESDAY, WEDNESDAY,
            THURSDAY, FRIDAY, SATURDAY, SUNDAY };
int main()
{
    enum days d = WEDNESDAY;
    printf("%d\n", d);           // 2
    printf("%lu", sizeof(d));    // 4

    return 0
}
```

Declaring Enumerations

Live demos

Structures

- Structures are a set of related variables under one name

    - Declared with the keyword **struct**

    - Structure variables may be of different type

```
struct Person
{
    char *name;
    int age;
};
```

Same as enclosing code in include guard

Accessing Structure Members

- There are two ways to access structure members

  - **.** returns the value of the member

```
struct Person p;
p.name = strdup("Emily");
p.age = 18;
```

  - **->** dereferences a struct pointer and returns the member

```
struct Person *p = malloc(sizeof(struct Person));
p->name = strdup("Emily");
p->age = 18;
```

Declaring Structures
Live demos

Unions

Unions

- A union is a special data type that stores multiple variables in the same memory location

  - Only one member should be used at a time

  - Used to save up memory

  - Example:

```
union Data {
    int i;
    float f;
    char str[20];
};
```

Unions – Example

```
union Data {
    int i;
    float f;
    char str[20];
};

int main() {
    union Data data;
    data.i = 10;
    data.f = 220.5;
    strcpy( data.str, "C Programming");

    printf( "data.i : %d\n", data.i); // 1917853763
    printf( "data.f : %f\n", data.f); // 4122360580327794860452759...
    printf( "data.str : %s\n", data.str) // C Programming

    return 0;
}
```

Changing one variable corrupts the value of others

Bit Fields

- Bit fields allow packing data into memory less than a byte

  - The memory will always be at least 1 byte in size

```
struct Status {
    unsigned char isValidUsername : 1; // Can be 0 or 1
    unsigned char isValidPassword : 1;
};
```

Values are stored in 2 bits of memory

  - Used to save up memory

  - Slower than usual, the processor needs to make bit manipulations to access the exact bits

Bit Fields – Example

```c
typedef struct {
    unsigned char health : 4; // 0..10
    unsigned char direction : 2;  // 0-North, 1-West, 2-South, 3-East
    unsigned char lives : 2;  // 0..3
} CharacterInfo;

int main() {
    CharacterInfo charInfo;
    charInfo.health = 10;
    charInfo.lives = 3;
    charInfo.direction = 3;

    printf("Direction: %d, Lives: %d, Health: %d\n",
        charInfo.direction, charInfo.lives, charInfo.health);
    printf("Memory: %lu", sizeof(CharacterInfo)); // 1
    ...
```

Makefile – Example

Tab (not space) indent is required

```
                        Makefile
program: main.o functions.o
        gcc main.o functions.o -o program
```

- Usually named Makefile

- Tells the compiler to:

  - Compile `main.c` and `functions.c` into object files

  - Link `main.o` and `functions.o` into a single executable – `program`

- Executed with the `make` command (no additional arguments)

C Programming – Advanced Topics

Questions?

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