CPSC 259: Data Structures and Algorithms for Electrical Engineers

Structs (Records)

Textbook References: (a) Etter: start of Chapter 7 (b) Thareja (*first edition*): 7.1 – 7.4 (c) Thareja (*second edition*): 5.1 – 5.4

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Learning Goals

- Define and use records (e.g., structs in C) in an implementation with dynamic memory allocation.
- Become more familiar with addresses and pointers in C.

Records (Structures)

- Often, we need to deal with related data (i.e., several attributes) about a specific entity. For example:
 - an **employee** is identified by a unique employee number, and has the following additional (possibly non-unique) attributes: name, street address, city, province, postal code, salary, job title, etc.
- A structure is declared using the keyword struct followed by a structure name. All the variables of a structure are declared within the structure. A structure type is defined by using the given syntax.

```
struct Employee {
    int empNum;
    char name[MAXLEN];
    double salary;
};
```

Records (Structures)

- The structure definition does not allocate any memory. It just gives a template that conveys to the C compiler how the structure is laid out in memory and gives details of the member names.
- Memory is allocated for the structure when we declare a variable of the structure. For example, we can define a variable of an employee by writing

```
struct Employee {
    int empNum;
    char name[MAXLEN];
    double salary;
};
```

struct Employee boss1;

Typedef

Employee

boss1;

• We can define a structure as a type so then we can declare it without using the struct keyword.

struct Employee boss1;

Method 1	Method 2
<pre>typedef struct{ int empNum; char name[MAXLEN]; double salary; } Employee;</pre>	<pre>struct Employee{ int empNum; char name[MAXLEN]; double salary; };</pre>
	typedef struct Employee Employee

Initialization of Structures

- Initializing a structure means assigning some constants to the members of the structure.
- The initializers are enclosed in braces and are separated by commas. Note that initializers match their corresponding types in the structure definition.

Employee former_boss = {5000, "Derek", 99250.75};

• When the user does not explicitly initialize the structure then C automatically does that. For int and float members, the values are initialized to zero and char and string members are initialized to the '\0' by default.

Accessing the Members of a Structure

• Each member of a structure can be used just like a normal variable, but its name will be a bit longer. A structure member variable is generally accessed using the '.' (dot operator).

• The syntax of accessing a structure member:

new_boss.empNum = 1000; strcpy(new_boss.name, "Ralph"); new_boss.salary = 125750.99;

Arrays of Structures

• The general syntax for declaring an array of structure can be given as:

Employee staff_junior[20];

• Now, to assign values to the ith staff, we will write:

staff_junior[0].empNum = 2000; strcpy(staff_junior[0].name, "Susan"); staff_junior[0].salary = 50000.00;

Declaring a Stand-alone Structure (pointers)

• Like in other cases, a pointer to a structure is never itself a structure, but merely a variable that holds the address of a structure. The syntax to declare a pointer to a structure can be given as

Employee * vice_president; vice_president = (Employee *) malloc(sizeof(Employee));

• To access the members of the structure, one way is to write /* get the structure, then select a member */

(*vice_president).salary += 10000.00; /* one way */

• An alternative to the above statement can be used by using 'pointing-to' operator (->)

vice_president->empNum = 1; /* another way */
vice_president->salary = 105000.00;

Declaring an Arrays of a Structure

/* Accessing the data using arrays */
staff_senior[i].empNum = 100 +i;

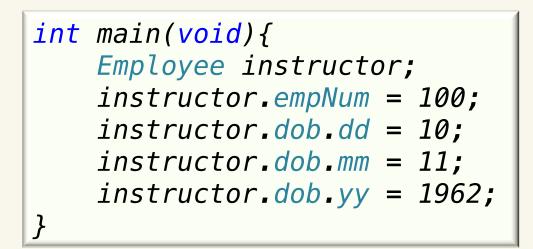
/* another way of accessing the data, via pointer arithmetic */
(staff_senior +i)->salary = 80000;/* parentheses needed */
(*(staff_senior+i)).salary *= 1.05; /* 5% pay increase */

Nested Structs

• A structure can be placed within another structure;

typedef	
int	dd;
int	<i>mm ;</i>
int	уу;
<pre>} Date;</pre>	

<pre>typedef struct{</pre>		
	int	empNum;
	char	<pre>name[MAXLEN];</pre>
	double	salary;
	Date	dob;
}	Employee;	



Passing a structure to a function call by value

• When a structure is passed as an argument, it is passed using call by value method. That is a copy of each member of the structure is made.

printEmp(new_boss);

void printEmp(Employee emp){
 printf("Employee Number: %d\n", emp.empNum);
 printf("Employee Name: %s\n", emp.name);
 printf("Employee Salary: \$%.2f\n\n", emp.salary);
}

Passing a structure to a function call by reference

• This is a very inefficient method especially when the structure is very big or the function is called frequently. Therefore, in such a situation passing and working with pointers may be more efficient.

printEmp_ptr(&new_boss);

void printEmp_ptr(Employee* emp){
 printf("Employee Number: %d\n", (*emp).empNum);
 printf("Employee Name: %s\n", (*emp).name);
 printf("Employee Salary: \$%.2f\n\n", (*emp).salary);
}

Please see employee_records.c

Structs (Records)

Clicker question

What is the size of the Employee struct given sizeof(int) =4, sizeof(char*)=8, and sizeof(double)=8? typedef struct{ int empNum;

- A. 12 bytes
- B. 16 bytes
- C. 20 bytes
- D. 32 bytes
- E. We can't estimate the size since we don't know how many characters are in the name field.

char* name;

} Employee;

double salary;

Clicker question

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} Employee;

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Clicker question What is stored in the "name" field in boss? Choose the best answer typedef struct{ int empNum

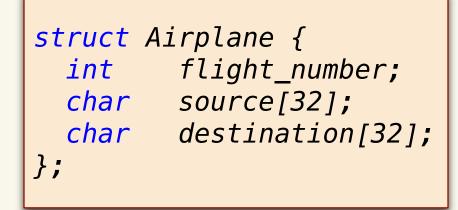
- int empNum; char* name; double salary; } Employee; Employee boss;
- A. The name field eventually contains a character string of some currently unknown length, so the size of "boss" will change.
- B. The name field eventually contains a character string of some currently unknown length, but the size of "boss" will not change.
- C. The name field is a pointer to another area of memory that eventually holds a character string of some currently unknown length, but the size of "boss" will not change.

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A running example

• Example of an Airplane structure.



• Declare and initialize a local record using the Airplane structure

struct Airplane AC={101, "Vancouver", "Calgary"};

```
struct Airplane AC;
AC.flight_number = 101;
strcpy(AC.source, "Vancouver");
strcpy(AC.destination, "Calgary");
```