Structure and Union Types
Chapter 10

Problem Solving & Program Design in C

Eighth Edition

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Chapter Objectives

- To learn how to declare a struct data type which consists of several data fields, each with its own name and data type
- To understand how to use a struct to store data for a structured object or record
- To learn how to use dot notation to process individual fields of a structured object
- To learn how to use structs as function parameters and to return function results
- To understand the relationship between parallel arrays and arrays of structured objects

User-Defined Structure Types

- record
  - a collection of information about one data object
- structure type
  - a data type for a record composed of multiple components
- hierarchical structure
  - a structure containing components that are structures

User-Defined Structure Types

Name: Jupiter

Diameter: 142,800 km

Moons: 16

Orbit time: 11.9 years

Rotation time: 9.925 hours

```
#define STRSIZ 10

typedef struct {
      char   name[STRSIZ];
      double diameter;            /* equatorial diameter in km    */
      int    moons;               /* number of moons              */
      double orbit_time,          /* years to orbit sun once      */
             rotation_time;       /* hours to complete one
                                        revolution on axis        */
} planet_t;
```

User-Defined Structure Types

Another syntax:

```
struct Planet {
        char name[70];
        double diameter;
        int moons;
        double orbit_time,
                rotation_time;
};
// in a function
struct Planet p1, p2;
```

User-Defined Structure Types

Name: Jupiter

Diameter: 142,800 km

Moons: 16

Orbit time: 11.9 years

Rotation time: 9.925 hours

I will always use this syntax

```
#define STRSIZ 10

typedef struct {
      char   name[STRSIZ];
      double diameter;          /* equatorial diameter in km    */
      int    moons;             /* number of moons              */
      double orbit_time,        /* years to orbit sun once      */
             rotation_time;     /* hours to complete one
                                     revolution on axis         */
} planet_t;
```

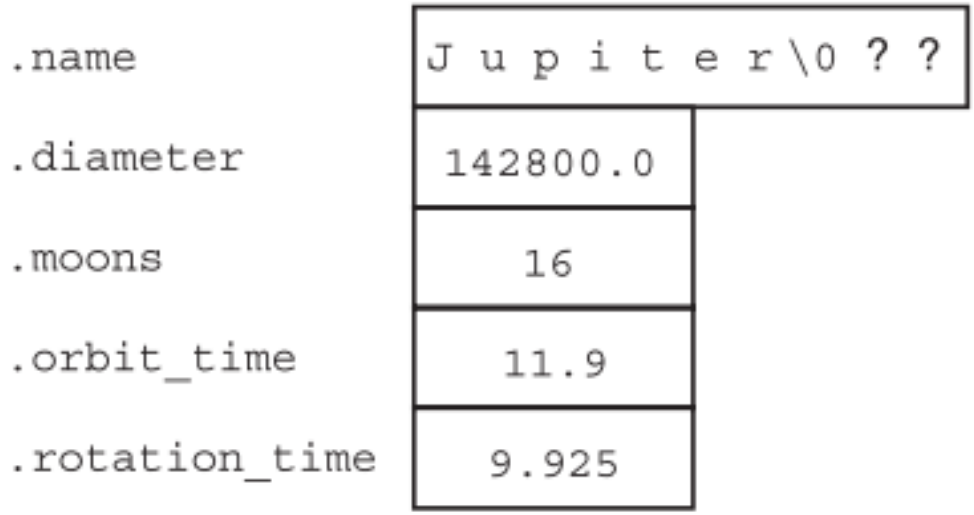
Individual Components of a Structured Data Object

- direct component selection operator
  - a period placed between a structure type variable and a component name to create a reference to the component

```
planet_t p1;
p1.moons = 10;
printf("p1 has %d moons\n", p1.moons);
```

```
strcpy(current_planet.name, "Jupiter");
current_planet.diameter = 142800;
current_planet.moons = 16;
current_planet.orbit_time = 11.9;
current_planet.rotation_time = 9.925;
```

Variable `current_planet`, a structure of type `planet_t`



Structure Data Type as Input and Output Parameters

- When a structured variable is passed as an input argument to a function, **all of its component values are copied** into the components of the function's corresponding formal parameter.

Structure Data Type as Input and Output Parameters

- When such a variable is used as an output argument, the address-of operator must be applied in the same way that we would pass output arguments of the standard types char, int, and double.

FIGURE 10.2 Function with a Structured Input Parameter

```
1.  /*
2.   * Displays with labels all components of a planet_t structure
3.   */
4.  void
5.  print_planet(planet_t pl) /* input - one planet structure */
6.  {
7.        printf("%s\n", pl.name);
8.        printf("  Equatorial diameter: %.0f km\n", pl.diameter);
9.        printf("  Number of moons: %d\n", pl.moons);
10.       printf("  Time to complete one orbit of the sun: %.2f years\n",
11.              pl.orbit_time);
12.       printf("  Time to complete one rotation on axis: %.4f hours\n",
13.              pl.rotation_time);
14. }
```

FIGURE 10.3 Function Comparing Two Structured Values for Equality

```
1.  #include <string.h>
2.
3.  /*
4.   * Determines whether or not the components of planet_1 and planet_2 match
5.   */
6.  int
7.  planet_equal(planet_t planet_1, /* input - planets to                    */
8.                planet_t planet_2) /*         compare                     */
9.  {
```

(continued)

FIGURE 10.3 (continued)

```
10.       return (strcmp(planet_1.name, planet_2.name) == 0    &&
11.               planet_1.diameter == planet_2.diameter       &&
12.               planet_1.moons == planet_2.moons             &&
13.               planet_1.orbit_time == planet_2.orbit_time   &&
14.               planet_1.rotation_time == planet_2.rotation_time);
15. }
```

Structure Data Type as Input and Output Parameters

- indirect component selection operator
  - the character sequence -> placed between a pointer variable and a component name creates a reference that follows the pointer to a structure and selects the component

FIGURE 10.4 Function with a Structured Output Argument

```
1.  /*
2.   * Fills a type planet_t structure with input data. Integer returned as
3.   * function result is success/failure/EOF indicator.
4.   *      1 => successful input of one planet
5.   *      0 => error encountered
6.   *      EOF => insufficient data before end of file
7.   * In case of error or EOF, value of type planet_t output argument is
8.   * undefined.
9.   */
10. int
11. scan_planet(planet_t *plnp) /* output - address of planet_t structure
12.                                         to fill                          */
13. {
14.       int result;
15.
16.       result = scanf("%s%lf%d%lf%lf", (*plnp).name,
17.                                        &(*plnp).diameter,
18.                                        &(*plnp).moons,
19.                                        &(*plnp).orbit_time,
20.                                        &(*plnp).rotation_time);
21.       if (result == 5)
22.             result = 1;
23.       else if (result != EOF)
24.             result = 0;
25.
26.       return (result);
27. }
```

FIGURE 10.5

Data Areas of main and scan_planet During Execution of `status = scan_planet (&current_planet);`

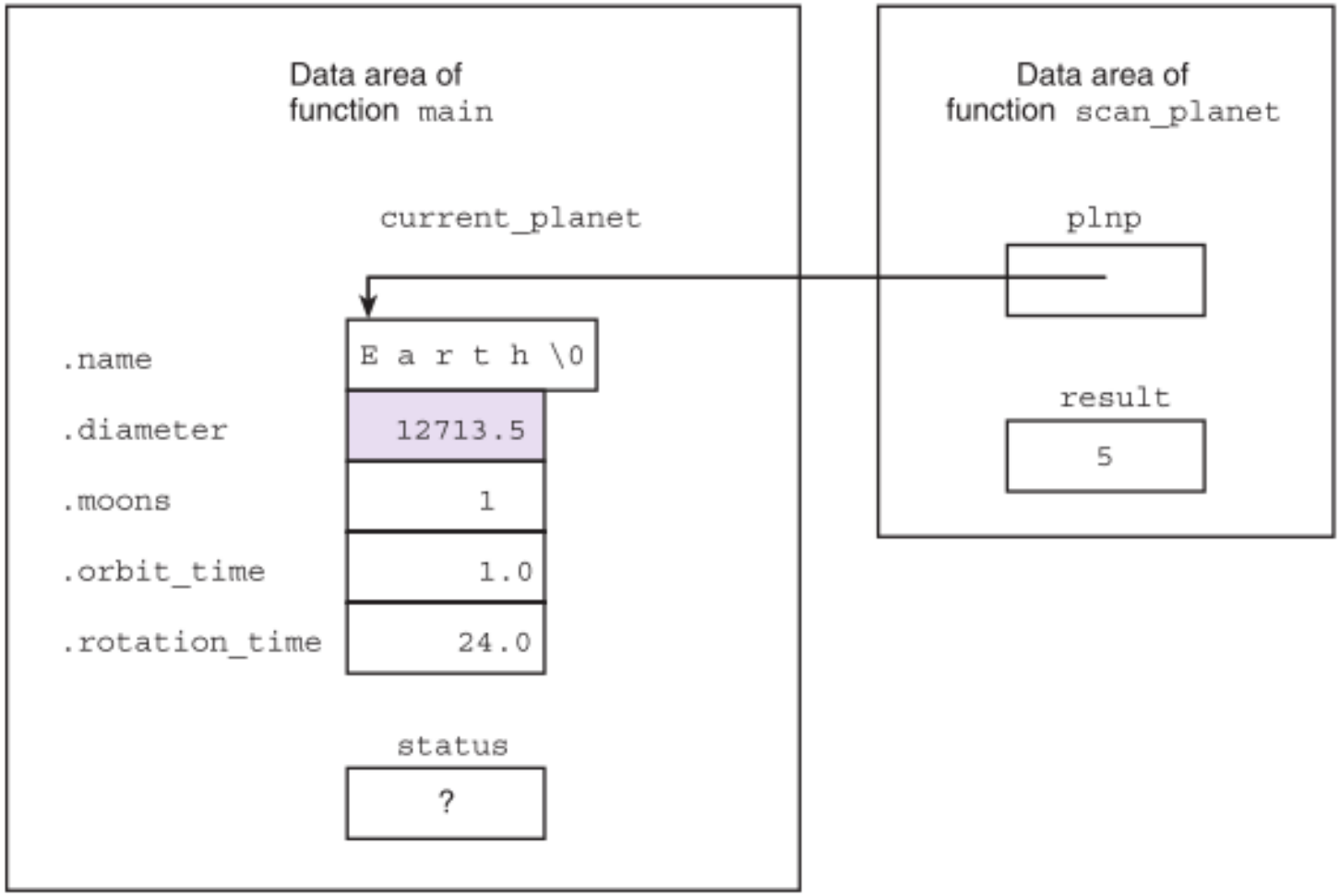


TABLE 10.2 Step-by-Step Analysis of Reference &(*plnp).diameter

Reference	Type	Value
`plnp`	`planet_t *`	address of structure that `main` refers to as `current_planet`
`*plnp`	`planet_t`	structure that `main` refers to as `current_planet`
`(*plnp).diameter`	`double`	`12713.5`
`&(*plnp).diameter`	`double *`	address of colored component of structure that `main` refers to as `current_planet`

Functions Whose Result Values are Structured

- A function that computes a structured result can be modeled on a function computing a simple result.

- A local variable of the structure type can be allocated, fill with the desired data, and returned as the function result.

Functions Whose Result Values are Structured

- The function does not return the *address* of the structure as it would with an array result.

- Rather, it returns the *values* of all components.

TABLE 10.1 Precedence and Associativity of Operators Seen So Far

Precedence	Symbols	Operator Names	Associativity
highest	`a[j] f( ... ) .`	Subscripting, function calls, direct component selection	left
	`++ --`	Postfix increment and decrement	left
	`++ -- !` `- + & *`	Prefix increment and decrement, logical not, unary negation and plus, address of, indirection	right
	`(`*type name*`)`	Casts	right
	`* / %`	Multiplicative operators (multiplication, division, remainder)	left
	`+ -`	Binary additive operators (addition and subtraction)	left
	`< > <= >=`	Relational operators	left
	`== !=`	Equality/inequality operators	left
	`&&`	Logical and	left
	`||`	Logical or	left
lowest	`= += -=` `*= /= %=`	Assignment operators	right

FIGURE 10.6 Function get_planet Returning a Structured Result Type

```
1.  /*
2.   * Gets and returns a planet_t structure
3.   */
4.  planet_t
5.  get_planet(void)
6.  {
7.        planet_t planet;
8.
9.        scanf("%s%lf%d%lf%lf", planet.name,
10.                              &planet.diameter,
11.                              &planet.moons,
12.                              &planet.orbit_time,
13.                              &planet.rotation_time);
14.       return (planet);
15. }
```

FIGURE 10.7 Function to Compute an Updated Time Value

```
1.  /*
2.   * Computes a new time represented as a time_t structure
3.   * and based on time of day and elapsed seconds.
4.   */
5.  time_t
6.  new_time(time_t time_of_day,    /* input - time to be
7.                                       updated                    */
8.           int    elapsed_secs)   /* input - seconds since last update */
9.  {
10.       int new_hr, new_min, new_sec;
11.
12.       new_sec = time_of_day.second + elapsed_secs;
13.       time_of_day.second = new_sec % 60;
14.       new_min = time_of_day.minute + new_sec / 60;
15.       time_of_day.minute = new_min % 60;
16.       new_hr = time_of_day.hour + new_min / 60;
17.       time_of_day.hour = new_hr % 24;
18.
19.       return (time_of_day);
20. }
```

Problem Solving with Structure Types

- abstract data type (ADT
  - a data type combined with a set of basic operations

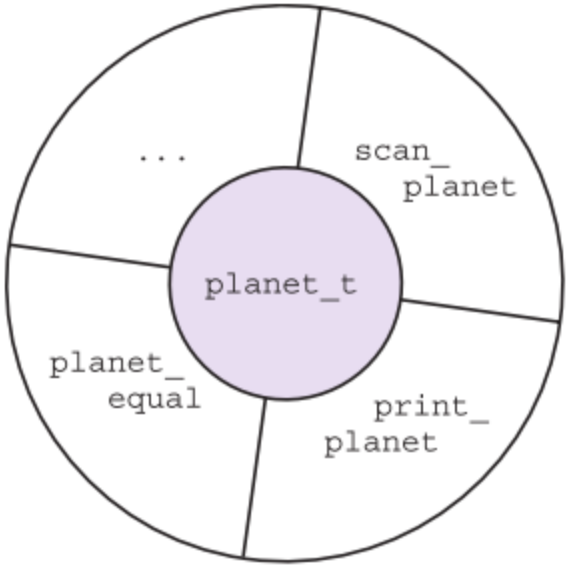


FIGURE 10.9

Data Type planet_t and Basic Operations

Parallel Arrays and Arrays of Structures

- A natural organization of parallel arrays with data that contain items of different types is to group the data into a structure whose type we define.

```
int    id[50];       /* id numbers and                          */
double gpa[50];      /* gpa's of up to 50 students              */
double x[NUM_PTS],   /* (x,y) coordinates of                    */
       y[NUM_PTS];   /*    up to NUM_PTS points                 */
```

```
#define MAX_STU 50
#define NUM_PTS 10

typedef struct {
      int    id;
      double gpa;
} student_t;

typedef struct {
      double x, y;
} point_t;

. . .

{
      student_t stulist[MAX_STU];
      point_t   polygon[NUM_PTS];
```

FIGURE 10.11

An Array of Structures