Structures and Union

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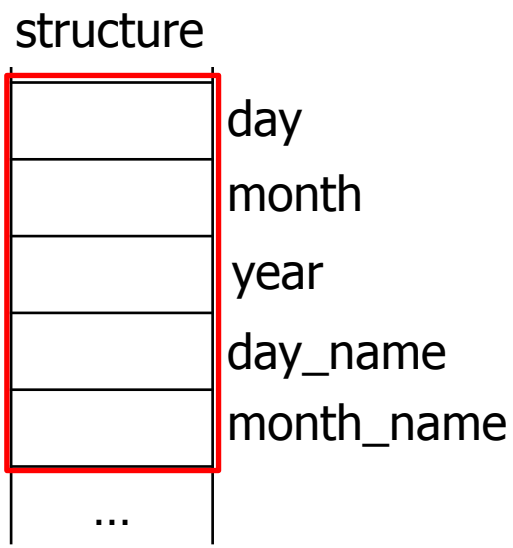
Review

- **Bitwise operations**
  - You need them for performance in terms of space and time
  - Shifts are equivalent to arithmetic
- **Enumeration**
  - you can define a set
  - each member is represented as an integer
- **Preprocessor directives**
  - process your program before it is compiled

STRUCTURE

Structures

```
struct {
   int     day, month, year;
   char    day_name[4]; /* Mon, Tue, Wed, etc. */
   char    month_name[4]; /* Jan, Feb, Mar, etc. */
} yesterday, today, tomorrow;

struct date {
   int     day, month, year;
   char    day_name[4];  /* Mon, Tue, Wed, etc. */
   char    month_name[4]; /* Jan, Feb, Mar, etc. */
};
struct date yesterday, today, tomorrow;
```



- **Like enum, it may define a new type**
- **Aggregate variables of different types**
- **Each member of a structure can be**
  - Array, structure, arrays of structures
- **You can build an array of structures**

Initialization

- **Similar to the array initialization, but uses values of different types.**

```
struct date{
   int     day, month, year;
   char    day_name[4]; /* Mon, Tue, Wed, etc. */
   char    month_name[4]; /* Jan, Feb, Mar, etc. */
};

struct date final = {15, 12, 2014, "Mon", "Dec"};

struct date remaining_classes[3] =
      {
         {8, 12, 2014, "Mon", "Dec"},
         {9, 12, 2014, "Tue", "Dec"},
         {15, 12, 2014, "Mon", "Dec"}
      }
```

Accessing a Member (1)

- **Dot (.) operator**
  - structure_name.member_name

```
struct {
   int     day, month, year;
   char    day_name[4]; /* Mon, Tue, Wed, etc. */
   char    month_name[4]; /* Jan, Feb, Mar, etc. */
} final;

…

final.day = 15;
final.month = 12;
final.year = 2014;
strcpy(final.day_name, "Mon");
strcpy(final.month_name, "Dec");
```

Accessing a Member (1)

- **-> operator**
  - pointer_to_structure->member_name
  - (*pointer_to_structure).member_name

```
struct {
   int    day, month, year;
   char   day_name[4]; /* Mon, Tue, Wed, etc. */
   char   month_name[4]; /* Jan, Feb, Mar, etc. */
} final, *final_p = &final;

…

final_p->day = 15;
final_p->month = 12;
(*final_p).year = 2014;
strcpy(final_p->day_name, "Mon");
strcpy(final_p->month_name, "Dec");
```

Declaration and Assignment

```
struct student tmp, *p = &tmp;
tmp.grade = 'A';
tmp.last_name = "Casanova";
tmp.student_id = 910017;
```

Expression	Equivalent expression	Conceptual value
tmp.grade	p->grade	A
tmp.last_name	p->last_name	Casanova
(*p).student_id	p->student_id	910017
*p->last_name + 1	(*(p->last_name)) + 1	'D'
*(p->last_name+2)	(p->last_name)[2]	's'

Scope Rule: Structure

- Similar to the scope rules of variables

```
int foo(struct date)
{
    …
}

int main(void)
{
    struct date
      {int d, m, y;}
    final;
    foo(final)
    …
```

invisible

```
struct date
    {int d, m, y;}
;

int foo(struct date)
{
    …

}

int main(void)
{
    struct final;
    foo(final)
    …
```

Using structures

- **Assignment works as long as two variables are of the same structure type**

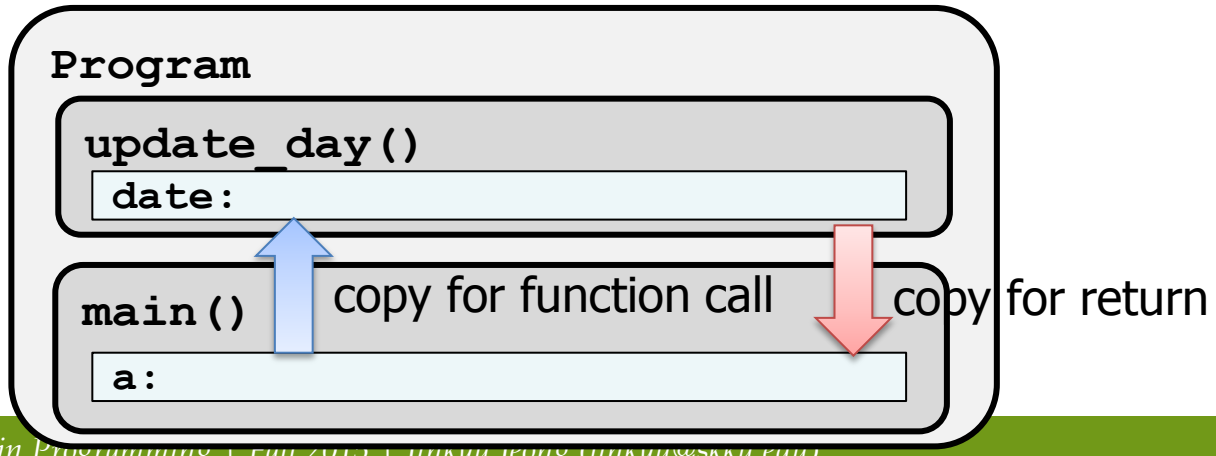
```
struct date a, b;
a = b;
```

- **Structure is more like a primitive type when used as a function parameter**
  - Call by value – the whole structure is copied
    - If it contains an array, the whole array is copied
    - Inefficient
    - This is one of reasons why there exists the -> operator
  - Call by reference – pointer is copied

Structure: Call-by-Value

- Copies whole data in a structure

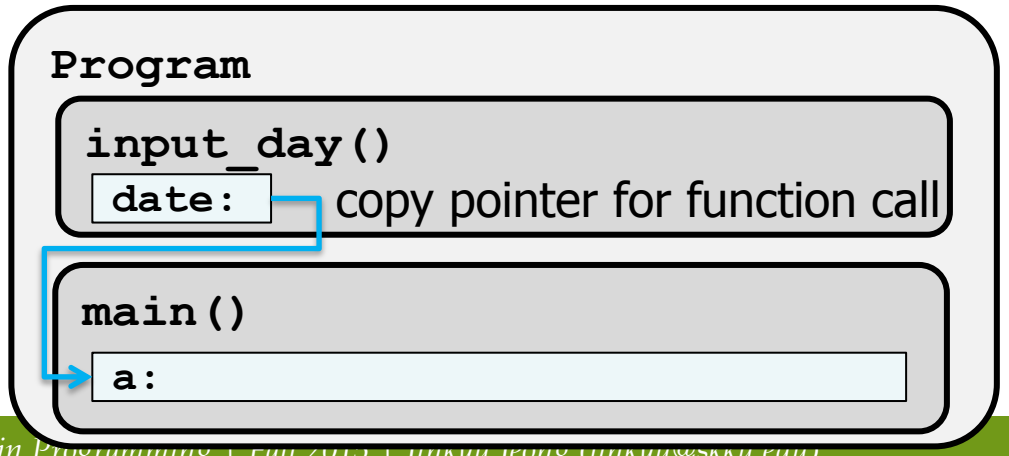
```
struct date update_day(struct date date) {
    scanf("%d %d %d %s %s", &date.day, &date.mon,
         &date.year, date.day_name, date.mon_name);
    return date;
}
int main(void) {
    struct date a = {1, 1, 2014, "Mon", "Jan"};
    a = update_day(a);
}
```



Structure: Call-by-Reference

- Copies reference (address) of a structure

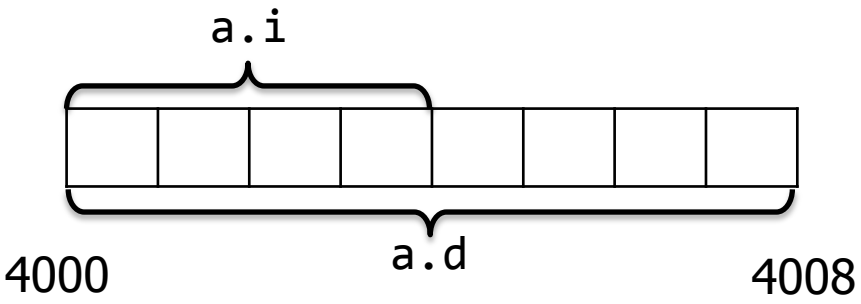
```
void update_day(struct date *date) {
    scanf("%d %d %d %s %s", &date->day, &date->mon,
         &date->year, date->day_name, date->mon_name);
    return;
}
int main(void) {
    struct date a = {1, 1, 2014, "Mon", "Jan"};
    update_day(&a);
}
```



UNION

Unions

```
union int_or_double {
    int i;
    double d;
} a;
```



- Similar to structure, but
- Defines a set of alternative values that may be stored in a shared location
- Programmer is responsible for interpreting the value correctly

Unions

- **To access a union member**
  - . operator
  - -> operator

- **The members of a structure and or a union can be array, structure, union**

- **Assignment, call-by-value, call-by-reference of a union can be done like a structure**

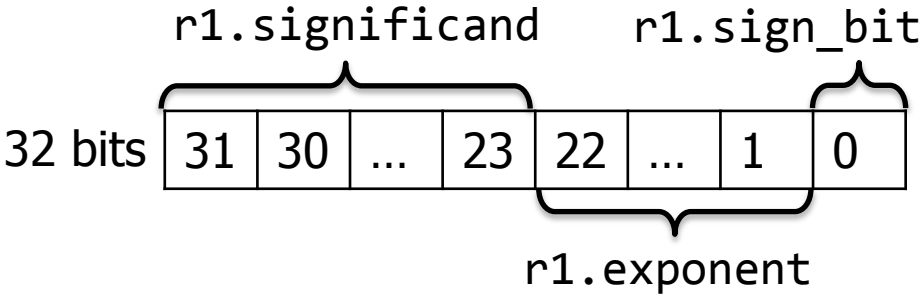
Unions: Example

```
#include <stdio.h>

typedef union int_or_float {
   int     i;
   float   f;
} number;

int main(void)
{
   number   n;

   n.i = 4444;
   printf("i: %10d     f: %16.10e\n", n.i, n.f);
   n.f = 4444.0;
   printf("i: %10d     f: %16.10e\n", n.i, n.f);
   return 0;
}
```

```
i:       4444     f: 6.2273703755e-42
i: 1166729216     f: 4.4440000000e+03
```

Bit Field

```
struct floating_number {
   unsigned    sign_bit : 1,
               exponent : 8,
               significand : 23;
} r1, r2;
```



- **A bit field is an int or unsigned member of a structure or a union**
  - Use . operator or -> operator to access members
- **Bit fields may be unnamed**
  - Unnamed bit field of width 0 is for alignment of the next word
- **Restrictions**
  - Array of bit fields
  - Address operator &

```c
#include <limits.h>
#include <stdio.h>

typedef struct {
   unsigned   b0 : 8, b1 : 8, b2 : 8, b3 : 8;
} word_bytes;

typedef struct {
   unsigned
      b0 : 1, b1  : 1, b2  : 1, b3  : 1, b4  : 1, b5  : 1, b6  : 1,
      b7 : 1, b8  : 1, b9  : 1, b10 : 1, b11 : 1, b12 : 1, b13 : 1,
      b14: 1, b15 : 1, b16 : 1, b17 : 1, b18 : 1, b19 : 1, b20 : 1,
      b21: 1, b22 : 1, b23 : 1, b24 : 1, b25 : 1, b26 : 1, b27 : 1,
      b28: 1, b29 : 1, b30 : 1, b31;
} word_bits;

typedef union {
   int          i;
   word_bits    bit;
   word_bytes   byte;
} word;
```

```c
word w = {0};
w.i = 'A';
putchar(w.i);
w.byte.b0 = 'A';
putchar(w.i);
w.bit.b6 = 1; w.bit.b0 = 1;
putchar(w.i);
```

```
AAA
```