CSE-207

Structures

Structures

- Essential for building up “interesting” data structures — e.g.,
    - Data structures of multiple values of different kinds
    - Data structures of indeterminate size
- Essential for solving “interesting” problems
    - Most of the “real” problems in the *C* world

Definition — *Structure*

- A collection of one or more variables, typically of different types, grouped together under a single name for convenient handling

- Known as **`struct`** in *C* and *C*++

struct

- Defines a new *type*
  - A new kind of data type that compiler regards as a unit.

```
struct motor {
  float volts;    //voltage of the motor
  float amps;     //amperage of the motor
  int phases;     //# of phases of the motor
  float rpm;      //rotational speed of motor
};     //struct motor
```

struct

- Defines a new *type*

Name of the type

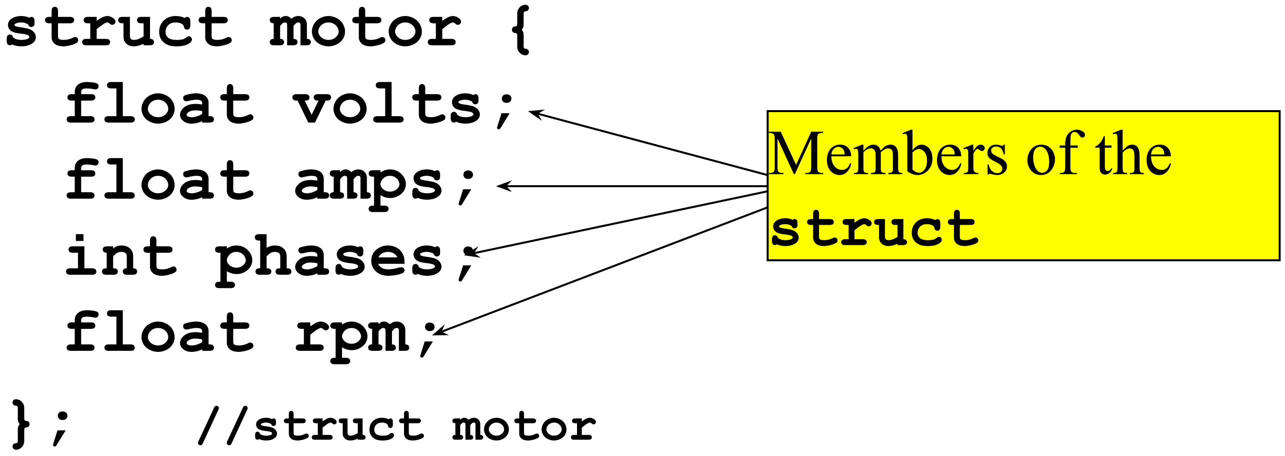
tag

Note:– name of type is optional if you are just declaring a single **struct**

```
struct motor {
  float volts;  //voltage of the motor
  float amps;   //amperage of the motor
  int phases;   //# of phases of the motor
  float rpm;    //rotational speed of motor
};    //struct motor
```

struct

- Defines a new *type*



```
struct motor {
  float volts;
  float amps;
  int phases;
  float rpm;
};    //struct motor
```

Members of the **struct**

Declaring **struct** variables

```
struct motor p, q, r;
```

- Declares and sets aside storage for three variables – **p**, **q**, and **r** – each of type **struct motor**

```
struct motor M[25];
```

- Declares a 25-element array of **struct motor**; allocates 25 units of storage, each one big enough to hold the data of one **motor**

```
struct motor *m;
```

- Declares a pointer to an object of type **struct motor**

Structures

```
struct ADate {
   int  month;
   int  day;
   int  year;
};

struct ADate date;

date.month = 9;
date.day = 1;
date.year = 2005;
```

To display the screen locations stored in the structure Adate,
printf("%d, %d, %d", **date.month, date.day, date.year**);

What are the Advantage ??

```
struct ADate {
   int  month;
   int  day;
   int  year;
};

struct ADate date1, date2;

date1.month = 9;
date1.day = 1;
date1.year = 2005;

date2 = date1 ;

date2.month = date1.month;
date2.day = date1.day;
date2.year = date1.year;
```

More Examples

-
  ```
  struct SSN {
          int first_three;
          char dash1;
          int second_two;
         char dash2;
         int last_four;
     };
  struct  SSN  customer_ssn ;
  ```

-
  ```
  struct date {
    char month[2];
    char day[2];
    char year[4];
    } current_date ;
  ```

-
  ```
  struct time {
             int hours;
             int minutes;
             int seconds;
           }  time_of_birth = { 8, 45, 0 };
  ```

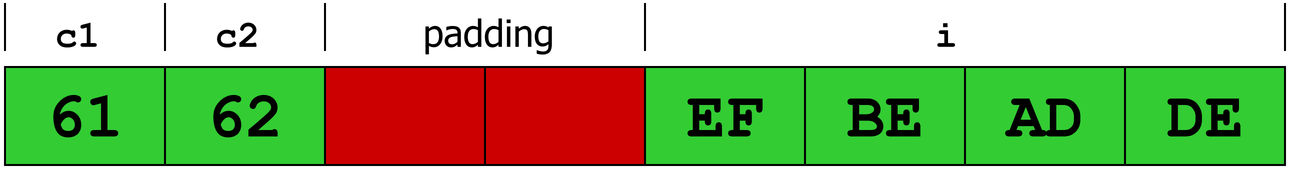
Structure Representation & Size

- `sizeof(struct …) =`
- sum of `sizeof(field)`
- + alignment padding

  Processor- and compiler-specific

```
struct CharCharInt {
   char  c1;
   char  c2;
   int   i;
} foo;

foo.c1 = 'a';
foo.c2 = 'b';
foo.i  = 0xDEADBEEF;
```



c1	c2	padding		i			
61	62	🟥	🟥	EF	BE	AD	DE

x86 uses “little-endian” representation

Accessing Members of a `struct`

`Repeat`

```
struct motor {
float volts;
float amps;
int phases;  otor
float rpm;
};
```

- Let

```
struct motor p;
struct motor q[10];
```

- Then

`p.volts` — is the voltage

`p.amps` — is the amperage

`p.phases` — is the number of phases

`p.rpm` — is the rotational speed

`q[i].volts` — is the voltage of the `i`th motor

`q[i].rpm` — is the speed of the `i`th motor

Accessing Members of a **`struct`** (continued)

- Let

```
struct motor *p
```

- Then

Why the parentheses?

`(*p).volts` — is the voltage of the **`motor`** pointed to by **`p`**

`(*p).phases` — is the number of phases of the **`motor`** pointed to by **`p`**

Accessing Members of a **`struct`** (continued)

- Let

  `struct mo`

Because '**.**' operator has higher precedence than unary '*****'

- Then

  `(*p).vol` — is the voltage of the **`motor`** pointed to by **`p`**

  `(*p).phases` — is the number of phases of the **`motor`** pointed to by **`p`**

Accessing Members of a `struct` (continued)

- Let

```
struct motor *p;
```

- Then

```
(*p).volts
```

to

```
(*p).phases
```

```
mo
```

Reason:– you really want the expression

```
m.volt * m.amps
```

to mean what you think it should mean!

Accessing Members of a **`struct`** (continued)

- The **`(*p).member`** notation is a nuisance
    - Clumsy to type; need to match **`( )`**
    - Too many keystrokes

- This construct is so widely used that a special notation was invented, i.e.,
    - **`p->member`**, where **`p`** is a pointer to the structure

Previous Example Becomes …

- Let

  `struct motor *p;`

- Then

  `p -> volts` — is the voltage of the **`motor`** pointed to by **`p`**

  `p -> phases` — is the number of phases of the **`motor`** pointed to by **`p`**

Operations on `struct`

- Copy/assign

```
struct motor p, q;
p = q;
```

- Get address

```
struct motor p;
struct motor *s
s = &p;
```

- Access members

```
p.volts;
s -> amps;
```

Initialization of a `struct`

- Let

```
struct motor {
    float volts;
    float amps;
    int phases;
    float rpm;
};    //struct motor
```

- Then

```
struct motor m = {208, 20, 3, 1800};
```

initializes the `struct`

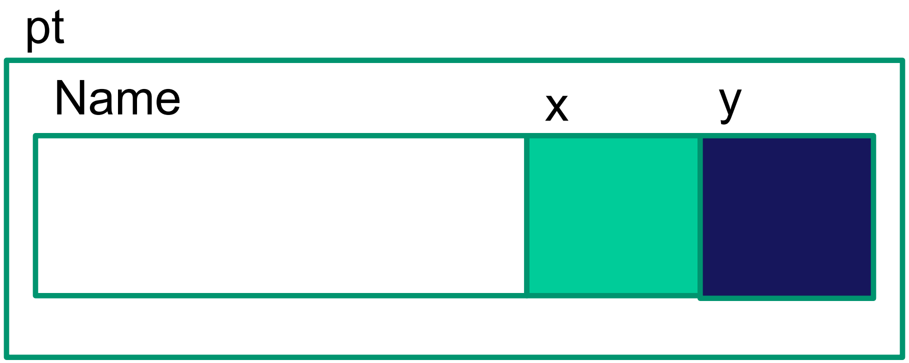
Why `structs` AGAIN???

- Open-ended data structures
  - E.g., structures that may grow during processing
  - Avoids the need for `realloc()` and a lot of copying
- Self-referential data structures
  - Lists, trees, etc.

Nesting Structures

```
struct Point {
      char name[30];
      int x;
      int y;
};
```

struct Point pt;

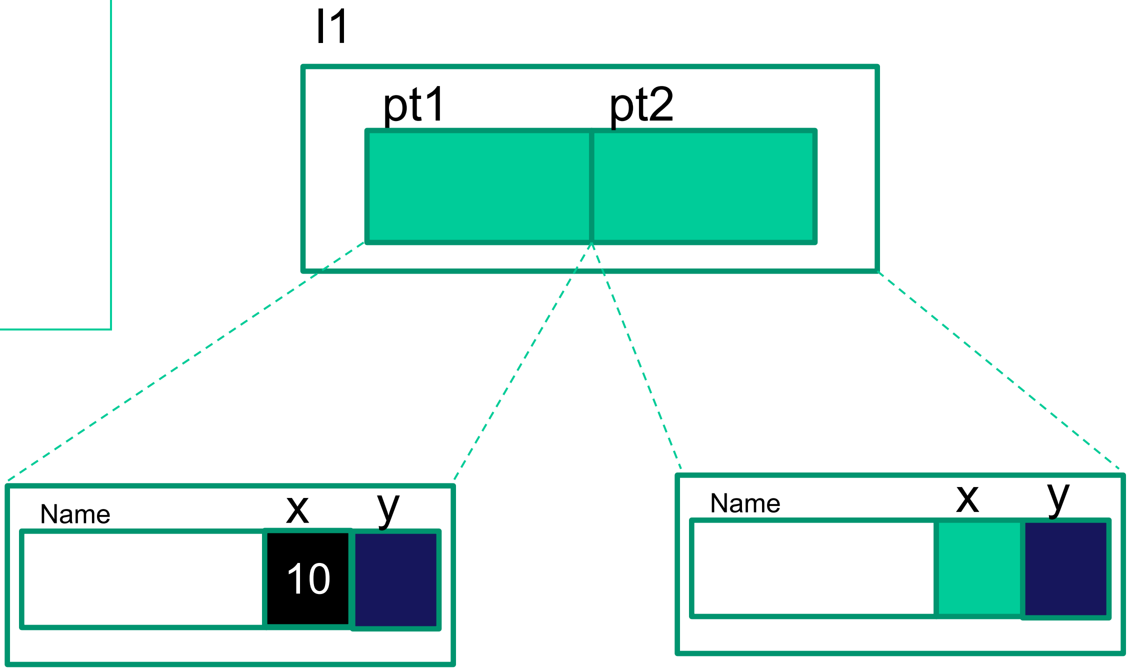


```
struct Line {
      struct Point pt1;
      struct Point pt2;
};
struct Line l1;
```

Nesting Structures

```
struct Point {
      char name[30];
      int x;
      int y;
};
```

```
struct Line {
      struct Point pt1;
      struct Point pt2;
};
struct Line l1;
```



To Access the Elements

```
l1.pt1.x=10;
```

Array of Structures

```
struct Point {
        char name[30];
        int x;
        int y;
};
```

- Array of Structures act like any other array.

```
struct Point pt[3];
```

```
pt[0].name = “A”;
pt[0].x = 0;
pt[0].y = 1;
```

```
pt[1].name = “B”;
pt[1].x = 4;
pt[1].y = 1;
```

```
pt[2].name = “mid”;
pt[2].x = (pt[0].x + pt[1].x)/2;
pt[2].y = (pt[0].y + pt[1].y)/2;
```

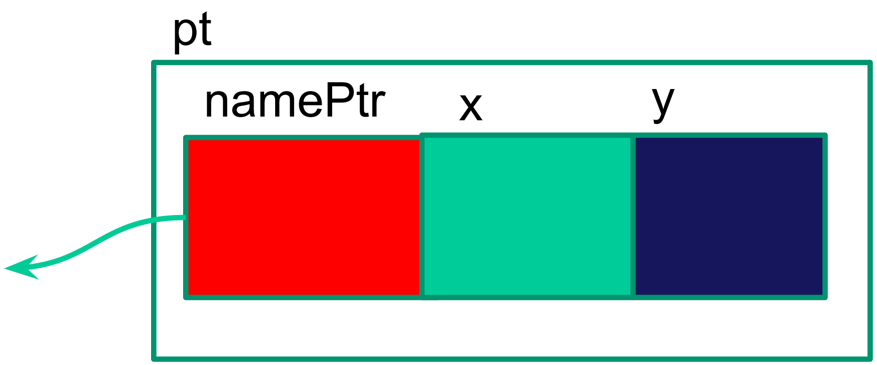
- Memory occupied: the dimensions of the array multiply by sizeof(struct tag)
  - (Remember) sizeof() is compile time function

Pointers in Structures

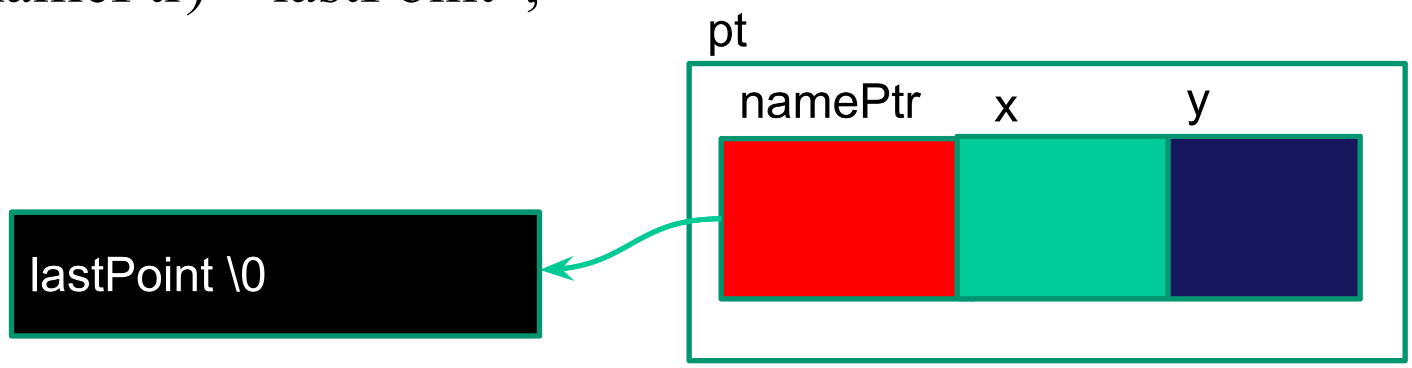
- A structure can have a pointer as its member

```
struct Point {
        char *namePtr;
        int x;
        int y;
};
```

```
struct Point pt;
```



```
pt.namePtr=(char *) malloc(20*sizeof(char));
*(pt.namePtr)=“lastPoint”;
```



Pointer to Structures

- A pointer to a structure can be defined

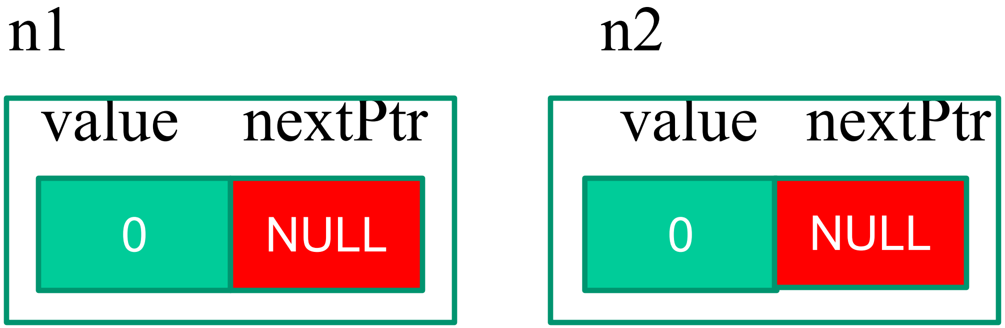
```
struct Point p1, *ptr;
ptr=&p1;
```

p1.x=10 ≡ ptr□x =10 ≡ (*ptr).x=10 ≡ (&p1)□x = 10

Self referencing Structures

- Useful in data structures like trees, linked lists.
- It is illegal for a structure to contain an instance of itself.
  - Solution: Have a pointer to another instance.

```
struct lnode {          /* the linked list node */
        int value;
        struct lnode *nextPtr; /* pointer to next node */
} n1,n2;
```



n1

value nextPtr

0 NULL

n2

value nextPtr

0 NULL

Example

```
struct item {
  char *s;
  struct item *next;
}
```

Yes! This is legal!

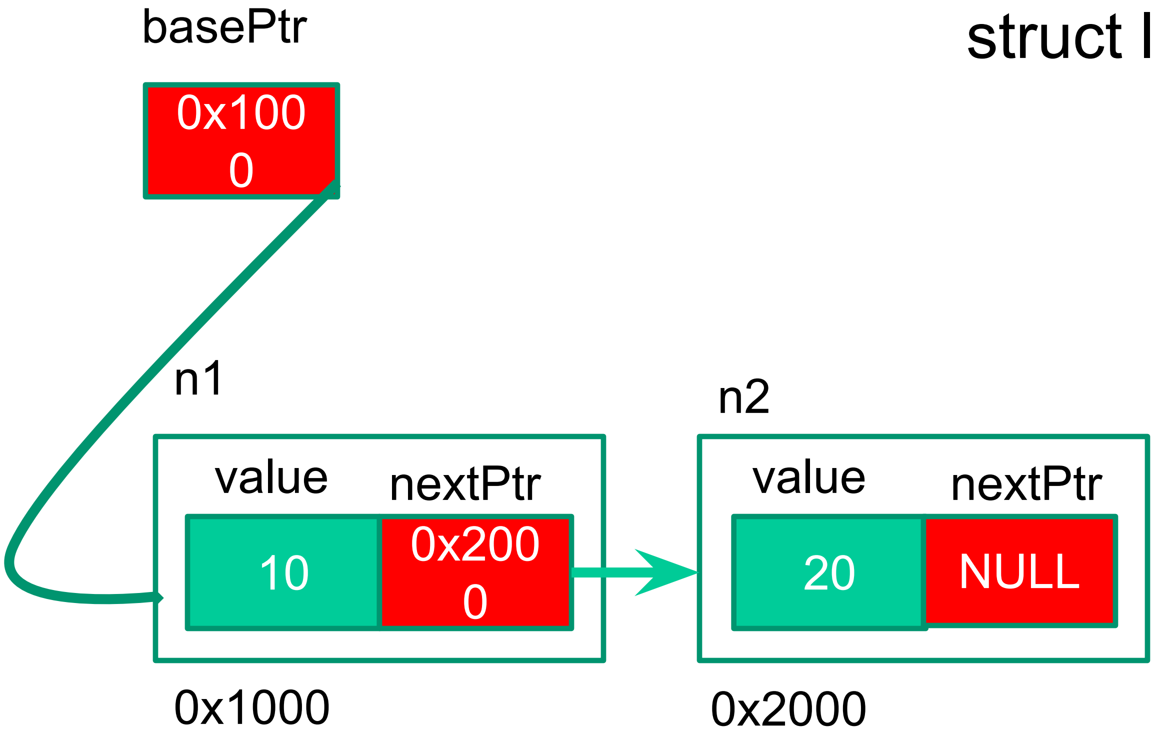
- I.e., an **`item`** can point to another **`item`**
- … which can point to another **`item`**
- … which can point to yet another **`item`**
- … etc.

Thereby forming a *list* of **`items`**

Self referencing Structures

```
struct lnode {
        int value;
        struct lnode *nextPtr;
        } n1,n2;
```

```
n1.value=10;
n1.nextPtr=&n2;
n2.value=20;
n2.nextPtr=NULL;
struct lnode *basePtr=&n1;
```



Typedef

- Use **typedef** for creating new data type names

-
  ```
  typedef int length;
  ```

this the name length a synonym (alias) for int. Afterwards, you can do:

```
length x = 4;
```

- In context of structs, you can do:

```
struct Point {
int x;
int y;
};
typedef struct Point myPoint;
myPoint p1;
struct Point p2;
p1.x=10;
```

```
typedef struct Point *pointPtr;
pointPtr p1;
struct Point p2;
p2.x=20;
p1.x=10; ??
p1⍰x=10; ??
p1=&p2;
p1⍰x=10; ??
p1=(pointPtr) malloc(sizeof(struct Point));
p1⍰x=10; ??
```

```
typedef struct lnode {
        .
        .
} myNode;
myNode n1, *ptr;
```

```
typedef struct {
        .
        .
} myNode;
myNode n1, *ptr;
```

`typedef` (continued)

- `typedef` may be used to rename *any* type
  - Convenience in naming
  - Clarifies purpose of the type
  - Cleaner, more readable code
  - Portability across platforms
- E.g.,
  - `typedef char *String;`
- E.g.,
  - `typedef int size_t;`
  - `typedef long int32;`
  - `typedef long long int64;`

Very common in C and C++

Esp. for portable code!

Defined once in a **`.h`** file!

Questions?