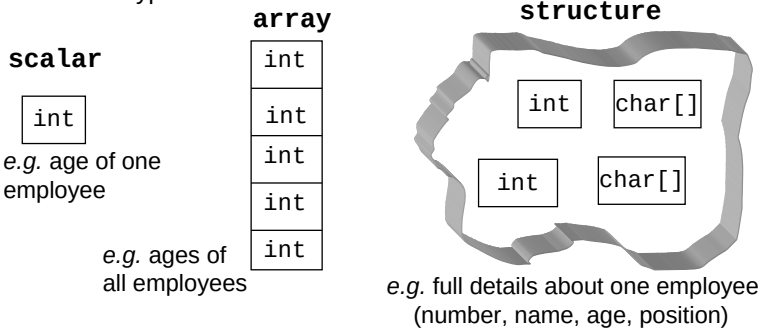
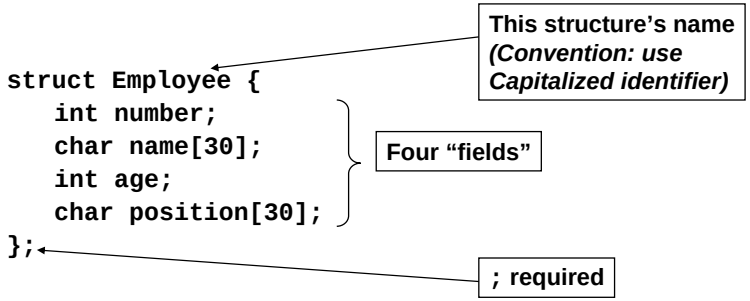
Structures

- A **scalar** holds a **single value** of a ***single type***
- An **array** holds **several values** of a ***single type***
- It is sometimes convenient to be able to group together items of information which are of ***different types***
  - Example: an employee's **number**, **name**, **age** and **position** are logically related, but these pieces of data are of different types and so are not suitable for storage in an array
- A **structure** allows the programmer to group together data items of different types



Defining Structures

- To define a structure we must create a **structure template:**

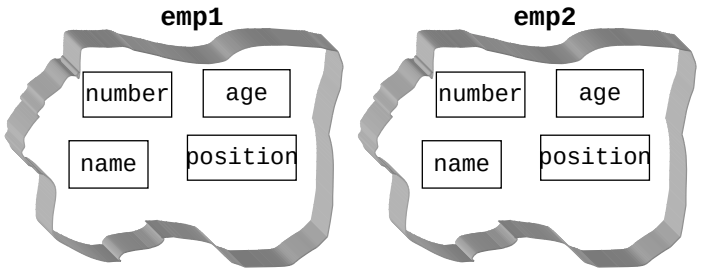


- **Does not allocate any memory** or define a new variable
- Just ***defines a new datatype,*** called **`Employee`**

- Now that we've defined the new datatype, we can define variables to be of type **`Employee`** (just as we can define variables to be of type **`int`**, **`char`**, **`float`**, …):

```
struct Employee emp1, emp2;
```

- This declares two variables, **`emp1`** and **`emp2`**, to be of type **`Employee`**



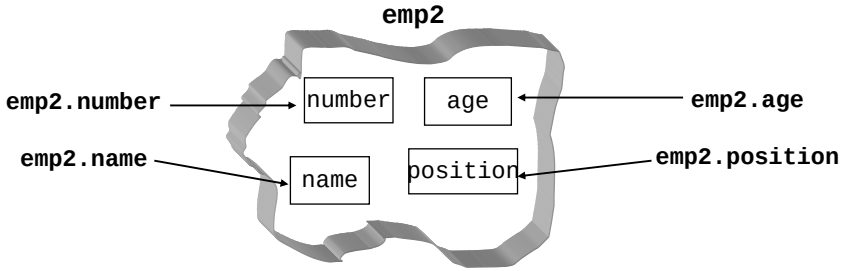
- Each of these structure variables has four fields:

  `number`, **`name`**, **`age`** and **`position`**

- In order to access structure fields, use the **field selection operator .**

```
emp1.number = 4321;
emp1.age = 34;
strcpy(emp1.name, "John Smith");
printf("what is %d's position:", emp1.number);
scanf("%s", emp1.position);
```

- Each member can be treated just like any other value of that datatype: can use string functions on **`name`** and **`position`**, can use **`age`** and **`number`** for arithmetic, etc.
  - Similar to arrays: if **`a[]`** is an array of **`float`**s, then **`a[i]`** can be treated just like a "normal" **`float`** for any valid subscript **`i`**



- If we wanted to print out the contents of this structure we could do it as follows:

```
printf("employee number: %d\n", emp2.number);
printf("\tname: %s\n", emp2.name); /* \t means tab */
printf("\tage: %d\n", emp2.age);
printf("\tposition: %s\n", emp2.position);
```

- Often a good idea to define a function to print out structures of this type (saves you rewriting this over and over; makes your program easier to understand, improve, debug, …):

```
void printEmployee (struct Employee e){
  printf("employee number: %d\n", e.number);
  printf("\tname: %s\n", e.name);
  printf("\tage: %d\n", e.age);
  printf("\tposition: %s\n", e.position);
}
```

- Note: **`printEmployee()`** has to know what an **`Employee`** structure is...


```
#include <stdio.h>
struct Employee {
 int number;
 char name[30];
 int age;
 char position[30];
};
void printEmployee (struct Employee e){
  printf("employee number: %d\n", e.number);
  printf("\tname: %s\n", e.name);
  printf("\tage: %d\n", e.age);
  printf("\tposition: %s\n", e.position);
}
main(){
  struct Employee emp;
  emp.number = 4321;
  emp.age = 34;
  strcpy(emp.name, "John Smith");
  printf("what is %d's position:", emp.number);
  scanf("%s", emp.position);
  printEmployee(emp);
}
```

Produces the screen output:

```
what is 4321's position:lecturer
employee number: 4321
        name: John Smith
        age: 34
        position: lecturer
```

Note: this is an example of a *call-by-value* function call


```
#include <stdio.h>
struct Employee {
 int number;
 char name[30];
 int age;
 char position[30];
};
void zapEmployee (struct Employee *pe){
  (*pe).number=-1;
  strcpy((*pe).name, "invalid");
  (*pe).age=-1;
  strcpy((*pe).position, "invalid");
}
void printEmployee (struct Employee e){
  printf("employee number: %d\n", e.number);
  printf("\tname: %s\n", e.name);
  printf("\tage: %d\n", e.age);
  printf("\tposition: %s\n", e.position);
}
main(){
  struct Employee emp;
  emp.number = 4321;
  emp.age = 34;
  strcpy(emp.name, "John Smith");
  printf("what is %d's position:", emp.number);
  scanf("%s", emp.position);
  printEmployee(emp);
  zapEmployee(&emp);
  printEmployee(emp);
}
```

Produces the screen output:

```
what is 4321's position:lecturer
employee number: 4321
        name: John Smith
        age: 34
        position: lecturer
employee number: -1
        name: invalid
        age: -1
        position: invalid
```

`pe` is a ***pointer*** to a structure of type **`Employee`**

Note: this is an example of a *call-by-address* function call

Pointers to Structures: A shorthand

Expressions like this are used a lot:

```
(*pe).number
```

C has a shorthand notation for this:

```
pe->number
```

Or more generally, if **`pstr`** is a pointer to a structure, and **`field`** is one of that structure's fields, then these two mean the same thing:

```
(*pstr).field
        ↕
pstr->field
```

EXAMPLE:

```
void zapEmployee (struct Employee *pe){
  pe->number = -1;
  strcpy(pe->name, "invalid");
  pe->age = -1;
  strcpy(pe->position, "invalid");
}
```

Nested Structures

- Quite complex structures can be put together by ***nesting structures***: using a structure for a field of another structure. For example, suppose we defined a structure template as follows:

```
struct Address {
     int number;
     char street[20];
     char city[20];
  };
```

- We could then incorporate this into our **Employee** structure template as follows:

```
struct Employee {
    int number;
    char name[30];
    int age;
    char position[30];
    struct Address addr;
};
```


Nested Structures (contd.)

- We can then declare a variable of this type:
  struct Employee emp;

- We could then assign values such as:

```
emp.number = 22; /* sets the Employee field */
emp.addr.number = 56; /* sets the Address field */
strcpy(emp.addr.street, "Elm Street");
```

  an **Address** structure

  that structure's **street** field

- Note that both **Employee** and **Address** have a field called **number**. These are different -- the structure will have two fields, one for each. This is OK -- there is no ambiguity, because you must include the appropriate "**.**" to tell the compiler which field you intend.

Arrays of structures

```
struct Company {
  int sales;
  int profit;
  char name[30];
  float PEratio;
};
struct Company companies[3];
```

This declares a 3-element array called companies, each of whose elements is a Company structure.