structs

C Programming and Software Tools

N.C. State Department of Computer Science

The Derived Data Types

- ✓ Arrays
- ✓ Pointers
- ➢ Structs
- ● (Enums)
- ● (Unions)

`structs`

- Example: a person has multiple attributes
  - name
  - weight
  - height
  - gender
  - ID number
  - age
  - etc.
- To indicate these are all part of the same entity, we define a `struct` data type for persons

Declaring Structure Tag

```
struct person {
    char name[LEN];
    int height;
    int weight;
    char gender;
    int idnum;
    short age;
    …
};
struct person
       persons[MAXP];
```

```
char *name[MAXP];
int height[MAXP];
int weight[MAXP];
char gender[MAXP];
int idnum[MAXP];
short age[MAXP];
   …
```

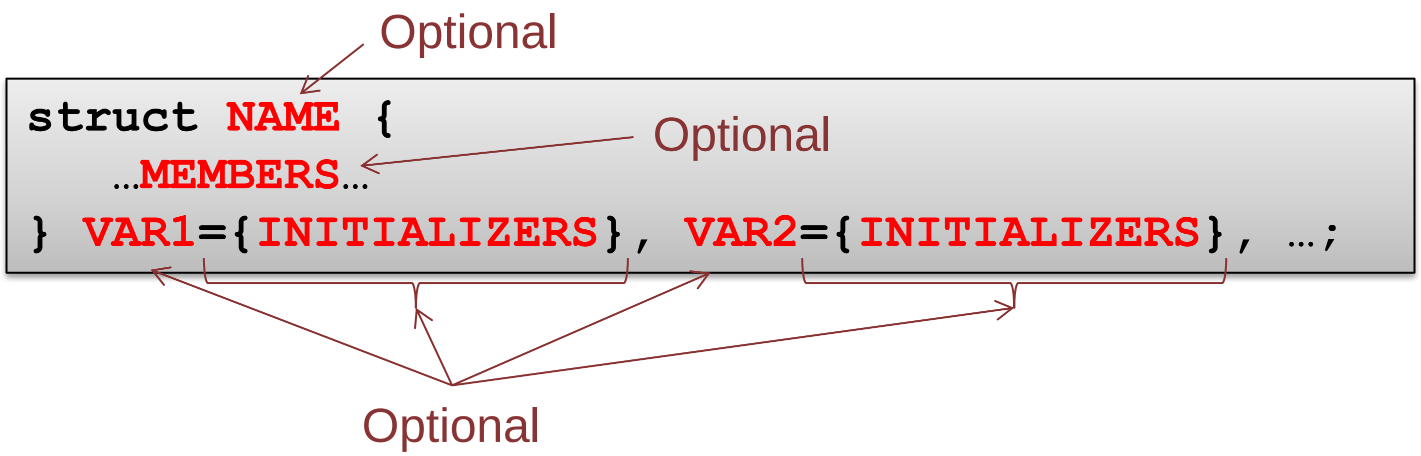
- Makes more sense than simply defining these fields individually, not indicating how they are related

Compared with Java

- members of a **`struct`** in C are very similar to instance fields of a class in Java
  - but there is no access specifier (**`public`**, **`private`**) for members of a **`struct`** (i.e., they are all public)
- Syntax for referring to both is the same

```
struct person person1;
person1.height = 72;
person1.weight = 180;
person1.gender = ‘M’;
…
```

Declaring structs


```
struct NAME {
    …MEMBERS…
} VAR1={INITIALIZERS}, VAR2={INITIALIZERS}, …;
```

- A struct ***may*** have a name
- A struct ***may*** have instances declared when it’s defined
- An instance ***may*** be initialized with values
- A struct ***may*** have members
  (but if it doesn’t, you’re probably dumb)

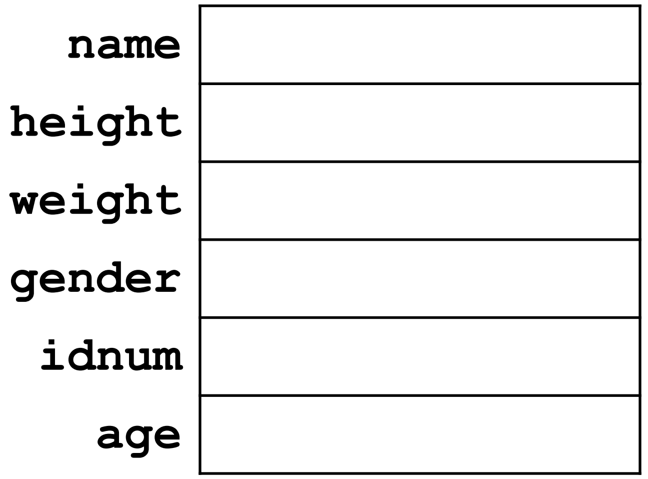
Example declarations

```
#define LEN 32

struct student {
    char name[LEN];
    float gpa;
};

struct {
    char name[LEN];
    float gpa;
} bob;

struct student {
    char name[LEN];
    float gpa;
} bob={"Bob Studentface", 3.5};
```

- Named struct
- Anonymous struct with one instance
- Named struct with one instance, initialized.

`struct`s in Memory

- `struct` *members* stored in memory in order declared
- Each member is allocated the amount of memory appropriate to its type
- Members are in same memory block
  - May be offsets



`struct` Name Space

- A **`struct`** is a new scope
- Two different **`struct`**s can have members with the same names

```
struct person {
    char name[LEN];
    int weight;
    int height;
    …
};
```

No conflict!

```
struct student {
    char name[LEN];
    char class;
    int creditHours;
    …
};
```

Initializing Named `structs`

Uninitialized

```
struct person person1;
```

Fully initialized

```
struct person person1 =
    {“Fred”, 72, 180, ‘M’, 12345, 20};
```

Partly initialized (version 1)

```
struct person person1 =
     {“Fred”, 72, 180, ‘M’};
```

…Initializing (cont’d)

Partly initialized (version 2)

```
struct person person1 =
    {.name = “Fred”,
     .height = 72,
     .gender = ‘M’,
     .idnum = 12345};
```

Exercise 16a

Hello, Struct!

- Declare a struct named position with integer members x, y, and z.
- Write the statement to initialize the struct to contain the coordinates (2,5,-3).
- Print the position to the console with the format “(%d,%d,%d)”.

Reminder: Go to course web page for link to exercise form.
Paste code into ideone.com and submit the link.

Referring to **structs** and members

Simple assignment to a **struct** member

```
person3.weight = 200;
```

Assignment to an entire **struct** (version 1)

```
person2 = person1;
```

Assignment to an entire **struct** (version 2)

```
person4 = (struct person)
     {"Mary",
       66,
       125,
      'F',
       98765,
       21};
```

If setting a struct after it's declared, you need to cast the braced stuff to the correct struct type.

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structs can contain structs

One struct…

```
struct date {
    unsigned short month;
    unsigned short day;
    unsigned int year;
};
```

Contained in
  another struct…

```
struct person-with-start {
   struct date start;
   char name[LEN];
   int height;
   int weight;
   char gender;
   int idnum;
   short age;
   …
};
```

`structs` can contain... (cont'd)

Referencing a struct within a struct

```
struct person-with-start p1;
...
p1.start.month = 8;
p1.start.day = 16;
p1.start.year = 2009;
```

Exercise 16b

Structs with structs

- Create a struct named box with members:
  - itemnum (int),
  - color (char * or char[25]),
  - p (struct position),
  - height, width, and depth (all ints).
- Write a statement to initialize a struct with values of 3 for itemnum, “red” for color, (1,2,3) for position, 3 for height, 2 for width, and 5 for depth.
- Print the strict with the format:

  “Item #%d (%s) POS=(%d,%d,%d) DIMS=(%d,%d,%d)”

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Arrays of `structs`

Example

```
…
int main () {
    struct person persons[100];

    persons[1] = getstruct(“Liz”);
    persons[2] = getstruct(“Jim”);
    (persons[2]).idnum = 23456;
    …
}
```

Parentheses needed? **No.**

Reminder: C Operator Precedence

Tokens	Operator	Class	Prec.	Associates
`a[k]`	subscripting	postfix	16	left-to-right
`f(...)`	function call	postfix		left-to-right
`.`	**direct selection**	postfix		left-to-right
`->`	**indirect selection**	postfix		left to right
`++ --`	increment, decrement	postfix		left-to-right
`(type){init}`	**literal**	postfix		left-to-right
`++ --`	increment, decrement	prefix	15	right-to-left
`sizeof`	size	unary		right-to-left
`~`	bit-wise complement	unary		right-to-left
`!`	logical NOT	unary		right-to-left
`- +`	negation, plus	unary		right-to-left
`&`	address of	unary		right-to-left
`*`	Indirection (dereference)	unary		right-to-left

Arrays of... (cont'd)

Example of an array of structs, each containing an array of structs...

```
struct person {
    …
    struct phonenumber pno[4];
};
struct person persons[MAXPERSONS];
```

```
struct phonenumber {
    short areacode;
    short exchange;
    short number;
    char type;
};
```

Initializing Arrays of `structs`

Example

```
struct person persons[100] = {
    { “Fred”, 72, 180, ‘M’, 0, 20 },
    { “Liz”, 63, 115, ‘F’, 33333, 19 },
    { “Mary”, 76, 180, ‘F’, 44444, 25,
      {{919, 515, 2044, ‘W’},
       {919, 555, 6789, ‘H’}} },
    [10] = {.name = “Bill”, .height = 70,
            .gender = ‘M’}
};
```

Referencing Arrays of structs

```
if (persons[4].pno[2].areacode == 919)
    …
```

Exercise 16c

Array of structs

- Declare an array of 100 boxes.
- Initialize a box at indexes 0 and 1 (your choice of values)
- Console output optional

Reminder: Go to course web page for link to exercise form.
Paste code into ideone.com and submit the link.

`structs` as Input Parameters

```
void printname ( struct person );

int main() {
   struct person person1 = {…};
   printname(person1);
   …
}

void printname( struct person p )
{
    printf("Name: %s\n", p.name);
}
```

Structs are passed by value, as usual

- i.e., a copy is made and passed to the function

structs as Return Values

- (finally!) The answer to how functions can return multiple results
  - one struct (with multiple members) = one result

structs as Return Values

```
struct person getstruct(char * name ) {
    struct person new;
    new.name = name;
    printf (“Enter height and weight for %s: ”,
               name);
    scanf(“%d %d” &(new.height), &(new.weight));
    return (new);
}
```

Parentheses needed? **No.**

```
int main () {
    …
    struct person person1 = getstruct(“Bob”);
    …
}
```

Exercise 16d

Return a struct

- Write a function which when given two structs (box), returns the one with the greater volume (but with position at 0, 0, 0 and color = “green”).

Reminder: Go to course web page for link to exercise form.
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structs Can Contain Pointers

```
struct person {
    char *name;
    …
} person1;

person1.name = "Donna";
printf("Name is %s\n", person1.name);
char initial = *person1.name;
```

Parentheses needed? **No.**

Be careful when assigning string values from another function.

Pointers to Structs

☠*common source of bugs* ☠
failure to use parens around (*p).m

```
struct person {
    …
} person1, *p;

p = &person1;

(*p).name = "Donna";
(*p).height = 65;
printf("Name is %s\n", (*p).name);
char initial = *(*p).name;
printf("Height is %d\n", (*p).height );
```

Parentheses needed? **YES.**

Does it suck that I need parentheses? **ALSO YES.**

Wouldn't it be cool if I didn't need them? **TOTALLY.**

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A New Operator

☠common source of bugs ☠
failure to use parens around (*p).m

- Unfortunately, $\underbrace{\texttt{*p.height} \neq}_{\text{the value pointed to by the member pp.height}} \underbrace{\texttt{(*p).height}}_{\text{the height of the person pointed to by pp}}$
- A new operator (for convenience):
  `(*a).b` can be replaced by `a->b`

```
…
p = &person1;

p->name = "Donna";
p->height = 65;
printf("Name is %s\n", p->name);
char initial = *p->name;
printf("Height is %d\n", p->height);
```

*What does * dereference?*

A New Operator… (cont'd)

- How about pointer to a **`struct`** containing pointer to a **`struct`** containing…? No problem!

```
struct person {
    …
    struct person *father;
    struct person *mother;
} persons[100], *p;
p = &persons[1];
p->father = &persons[22];
p->mother = &persons[45];

if ( p->father->age >= 65)
    …
printf("Mother: %s\n", p->mother->name );
```

Parentheses needed? **No.**

Exercise 16e

Pointers and structs

- Write a function that given two pointers to box structs, will update the one with the greater volume to position 0, 0, 0, and color "green". The function should be void.
- Write a main that:
  - Creates two box structs with reasonable test values
  - Prints all the members of both structs
  - Calls your function
  - Prints all the members of both structs again

Reminder: Go to course web page for link to exercise form.
Paste code into ideone.com and submit the link.

Any Questions?