structs

ITCS 2116: C Programming

College of Computing and Informatics

Department of Computer Science

`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

Declaring Structs

```
struct {
    char name[LEN];
    int height;
    int weight;
    char gender;
    int idnum;
    short age;
    …
} person1, person2;
```

Unnamed `struct`

`struct` variables

```
struct {
    char name[LEN];
    int height;
    int weight;
    char gender;
    int idnum;
    short age;
    …
} person1 = {"Bob",
70, 185, 'M', 5, 27},
person2 = {…};
```

Initialized `struct` variables

`structs` 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`

Unitialized

```
struct person person1;
```

Fully initialized

```
struct person person1 =
   {"Fred", 72, 180, 'M', 12345, 20};
```

Partially initialized (version 1)

```
struct person person1 =
    {"Fred", 72, 180, 'M'};
```

(see `struct_initialization.c` in *Code samples and Demonstrations* in *Canvas*)

…Initializing (cont'd)

Partially initialized (version 2)

```
struct person person1 =
    {.name = "Fred",
     .height = 72,
     .gender = 'M',
     .idnum = 12345};
```

(see **`struct_initialization.c`** in *Code samples and Demonstrations* in *Canvas*)

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};
```

This code uses a **compound literal**.

`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;
```

Arrays of `structs`

Example

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

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

(see **`struct_array1.c`** in *Code samples and Demonstrations* in *Canvas*)

Are 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)
    ...
```

Are parentheses needed?

No

(see **`struct_array2.c`** in *Code samples and Demonstrations* in *Canvas*)

`structs` as Input Parameters

```
void printname ( struct person );

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

void printname ( struct person p )
{
     (void) 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);
    (void) scanf("%d %d",
             &(new.height), &(new.weight));
    return (new);
}

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

Are parentheses needed? No

(see `struct_return.c` in *Code samples and Demonstrations* in *Canvas*)

`structs` Can **Contain** Pointers

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

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

Are parentheses needed? No

Be careful when assigning string values from another function.
Use the `strcpy()` or `strncpy()` function.

Pointers to Structs

```
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 );
```

(see `struct_pointer1.c` in *Code samples and Demonstrations* in *Canvas*)

Are parentheses needed?
Yes!

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

A New Operator: ->

- Unfortunately, `*p.height !=` `(*p).height`

the value pointed to by the member p.height

the height of the person pointed to by p

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

- 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);
```

(see `struct_pointer2.c` in *Code samples and Demonstrations* in *Canvas*)

*What does * dereference?*

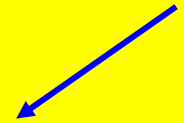
A New Operator… (cont'd)

- 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?



Enumerated Data Type

- Use for variables with small set of possible values, where actual encoding of value is unimportant

```
enum colors {red, blue, green, white, black};
enum colors mycolor;

mycolor = blue;
...
if ((mycolor == blue) || (mycolor == green))
   printf("cool color\n");
```

(see `colors.c` in *Code samples and Demonstrations* in *Canvas*)

Enumerated Data Type (cont'd)

Don't compare variables of different enumerated types - results **not** what you expect!

```
enum {blue, red, green, white, black}
  primarycolor;
enum {black, brown, orange, yellow}
  halloweencolor;

primarycolor = black;
halloweencolor = black;
if (primarycolor == halloweencolor)
   printf("Same color\n");
```

What will print?

(see `color_comparison.c` in *Code samples and Demonstrations* in *Canvas*)

Although you can interpret enumerated data types as integers, it is **not recommended**

Enumerated Data Type (cont'd)

Compared to **macros…**?

```
#define BLUE 0
#define RED 1
#define GREEN 2
#define WHITE 3
#define BLACK 4

int primarycolor;
primarycolor = RED;
…
if (primarycolor == RED) …
```

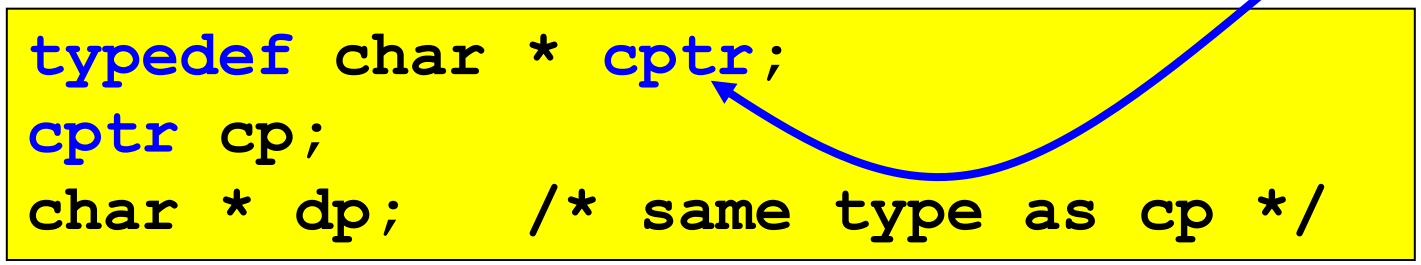
GNOME: *"If you have a list of possible values for a variable, do **not** use macros for them; use an enum instead and give it a type name"*

The `typedef` Statement

Assigns an alternate name (synonym) to a C data type

- more concise, more readable

`typedef` name, not a declaration of a variable



```
typedef char * cptr;
cptr cp;
char * dp;   /* same type as cp */
```

```
typedef struct {
   int val;
   cptr name;
   struct mystruct *next;
} llnode;
llnode entries[100];
```

The `typedef` Statement (cont'd)

Arrays can be **typedef**s

```
typedef int values[20];
values tbl1, tbl2;  /* two arrays, each with
                     * 20 ints */
```

- **`typedef`**s help make programs portable
  - to retarget a program for a different architecture, just redefine the typedefs and recompile
- Usually, **`typedef`**s are collected in a header file that is **`#include`**'d in all source code modules

`bool` variables

- Defines an integer variable that is restricted to store only the values 0 (`false`) and 1 (`true`)
  - attempt to assign any non-zero value will actually store the value 1

```
#include <stdbool.h>
…
bool test1;

test1 = ((c = getchar()) && (c != 'n'));

if (test1)     /* or (test1 == true) */
   …
```

The `union` Statement

- Defined like a `struct`, but only stores **exactly one** of the named members
  - motivation: use **less memory**
- Nothing in the `union` tells you which member is stored there!
  - usually, **another** variable indicates what is stored in the `union`

`union` Example

```
/* animal can have only one of the following */
union properties {
  unsigned short speed_of_flight;      // bird
  bool freshwater_or_saltwater;       // fish
  enum {VERY, SOME, NONE} hairiness;   // mammal
};

struct {
  unsigned char type;
  char * name;
  union properties info;
} animals[10];

animals[0].type = MAMMAL;
animals[0].name = "Polar Bear";
animals[0].info.hairiness = VERY;
```

References

- K. N. King, *C Programming: A Modern Approach*, 2nd Edition. W. W. Norton & Company. 2008.

- D.S. Malik, *C++ Programming: From Problem Analysis to Program Design*, Seventh Edition. Cengage Learning. 2014.