Week 12: Structures

Gaddis: 11.2-8

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Jill Seaman

Data Types

- A Data Type consists of:
  - set of values
  - set of operations over those values
- example: Integer
  - whole numbers, -32768 to 32767
  - +, -, *, /, %, ==, !=, <, >, <=, >=, ...
- Which operation is not valid for float?

Data Types (C/C++)

- Scalar (or Basic, Primitive) Data Types
  - atomic values
  - Integers:
    - ➡ short, int, long, char, bool
  - Floating Points:
    - ➡ float, double, long double
- Composite (or Aggregate) Types:
  - Arrays: ordered sequence of values of the same type
  - Structures: named components of various types

11.2 Structures

- Composite data type used to group multiple variables together into a unit.
- Example: student
  - ID Number
  - Name
  - Age
  - Major
- Each student has a value for each of these variables (or attributes).

Structures in C++

- Define the student as a struct in C++:

```
struct Student {
   int idNumber;
   string name;
   int age;
   string major;
};
```

- NOTE: semicolon after last curly bracket!
- A struct is a data type, and by convention the name is capitalized.
- The components are called “members” (or “fields”).

Defining structure variables

- So far we have defined a new data type, but we haven’t defined any variables of that type.
- To define a variable of type Student:

```
Student csStudent;
```

- Can define multiple variables of type Student:

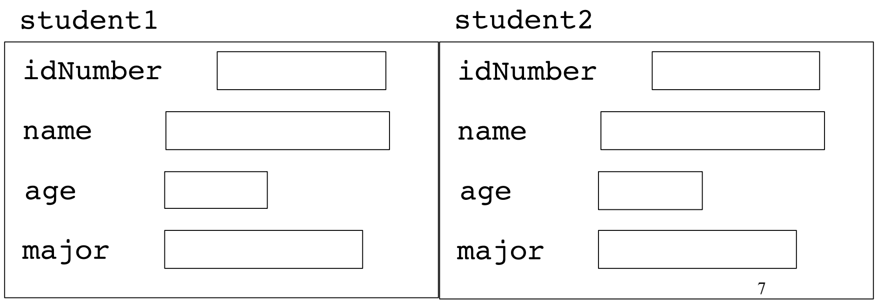
```
Student student1, student2, gradStudent;
```

- Each one has its own set of the member variables in the Student data type

Defining structure variables

- Each variable of type Student has its own set of the member variables from the Student data type

```
Student student1, student2;
```



student1

idNumber

name

age

major

student2

idNumber

name

age

major

11.3 Accessing Structure Members

- Use dot operator to access members of a struct variable:

```
student1.age = 18;
student2.idNumber = 123456;
cin >> gradStudent.name;
gradStudent.major = ”Rocket Science”;
```

- Member variables of structures can be used just like regular variables of the same type.

```
student1.age++;     //happy birthday
myFunc(student2.idNumber);
if (student1.age==student2.age) {
   ...
}
```

Operations over structures:

- Valid operations over entire structs:
  - assignment: `student1 = student2;`
  - function call: `myFunc(gradStudent,x);`
- Invalid operations over entire structs:
  - comparison: `student1 == student2`
  - output: `cout << student1;`
  - input: `cin >> student2;`
  - Must do these member by member!
- How is this different from Arrays?

Outputting & comparing structure variables

- Output the members one at a time:

```
cout << student1.idNumber << " ";
cout << student1.name << " ";
cout << student1.age << " ";
cout << student1.major << endl;
```

Output:

```
11122 Chris Johnson 19 Football
```

- Comparing two structs:

```
if (student1.idNumber == student2.idNumber &&
    student1.name == student2.name &&
    student1.age == student2.age &&
    student1.major == student2.major)
...
```

11.4 Initializing a Structure

- Struct variable can be initialized when it is defined:

```
Student student1 = {123456,”John Smith”,22, ”Math”};
```

- Must give values of members in order of the struct declaration.
- Can NOT initialize members in structure declaration, only variable definition:

```
struct StudentA {
   int id = 123456;            //ILLEGAL
   string name = “John Smith”; //ILLEGAL
}
```

```
struct EmployeePay  {
   string name;          // Employee name
   int empNum;           // Employee number
   double payRate;       // Hourly pay rate
   double hours;         // Hours worked
   double grossPay;      // Gross pay
};

int main()  {
   EmployeePay employee1 = {"Betty Ross", 141, 18.75};
   EmployeePay employee2 = {"Jill Sandburg", 142, 17.50};

   cout << fixed << setprecision(2);

   // Calculate pay for employee1
   cout << "Name: " << employee1.name << endl;
   cout << "Employee Number: " << employee1.empNum << endl;
   cout << "Enter the hours worked by this employee: ";
   cin >> employee1.hours;
   employee1.grossPay = employee1.hours * employee1.payRate;
   cout << "Gross Pay: " << employee1.grossPay << endl << endl;

   // Calculate pay for employee2
   cout << "Name: " << employee2.name << endl;
   cout << "Employee Number: " << employee2.empNum << endl;
   cout << "Enter the hours worked by this employee: ";
   cin >> employee2.hours;
   employee2.grossPay = employee2.hours * employee2.payRate;
   cout << "Gross Pay: " << employee2.grossPay << endl;
}
```

Initializes only name, empNum, and payRate

Sample output from previous program:

```
Name: Betty Ross
Employee Number: 141
Enter the hours worked by this employee:  40 [Enter]
Gross Pay: 750.00

Name: Jill Sandburg
Employee Number: 142
Enter the hours worked by this employee:  20 [Enter]
Gross Pay: 350.00
```

11.5 Arrays of Structures

- You can store values of structure types in arrays.

```
Student roster[40];  //holds 40 Student structs
```

- Each student structure is accessible via the subscript notation:

```
roster[0] = student1; //copies student1 to first elem.
```

- Members of structure accessible via dot operator

```
cout << roster[0].name << endl;
```

Arrays of Structures

- Arrays of structures processed in loops:

```
Student roster[40];

//input
for (int i=0; i<40; i++) {
  cout << "Enter the name, age, idNumber and "
       << "major of the next student: \n";
  cin >> roster[i].name >> roster[i].age
      >> roster[i].idNumber >> roster[i].major;
}

//output all the id numbers and names
for (int i=0; i<40; i++) {
  cout << roster[i].idNumber << endl;
  cout << roster[i].name << endl;
}
```

11.6 Nested Structures

- You can nest one structure inside another.

```
struct Address {
   string street;
   string city;
   string state;
   int zip;
};

struct Student {
   int idNumber;
   string name;
   Address homeAddress;
};
```

Nested Structures

- Use dot operator multiple times to get into the nested structure:

```
Student student1;
student1.name = “Bob Lambert”;
student1.homeAddress.city = “San Angelo”;
student1.homeAddress.state = “TX”;
```

- Or set up address structure separately:

```
Address a1;
a1.street = “101 Main St.”;
a1.city = “San Angelo”;
a1.state = “TX”;
a1.zip = 76903;

student1.name = “Bob Lambert”;
student1.homeAddress = a1;
```

11.7 Structures as function arguments

- Structure variables may be passed as arguments to functions.

```
void showStudent(Student x) {
   cout << x.idNumber << endl;
   cout << x.name << endl;
   cout << x.age << endl;
   cout << x.major << endl;
}

int main() {
  Student student1;

  //input information about student1 here

  showStudent(student1);
}
```

Note: Student declaration is global!!

Structures as function arguments

- By default, structure variables are passed by value (like most variables).
- If the function needs to change the value of a member, the structure variable should be passed by reference.

```
void happyBirthday(Student &s) {
   s.age++;
}
```

11.8 Returning a Structure from a Function

- A function may return a structure.

```
Student inputStudent(ifstream &fin) {
   Student result;
   fin >> result.idNumber;
   fin >> result.name;
   fin >> result.age;
   fin >> result.major;
   return result;
}
int main() {
   ifstream inFile;
   inFile.open(“students.dat”);
   Student student1 = inputStudent(inFile);
   for (int i=0; i<40; i++)
      roster[i] = inputStudent(inFile);
   inFile.close();
}
```

Note: always pass iostreams by reference!!

Example: nested structures

- Could have multiple structs using Address:

```
struct Student {
   int idNumber;
   string name;
   float gpa;
   Address homeAddress;
   Address campusAddr;
};

struct Faculty {
   int idNumber;
   string name;
   string officeLocation;
   Address address;
};
```

```
struct GradStudent {
   int idNumber;
   string name;
   int yearGraduated;
   Address homeAddress;
   Address campusAddr;
};
```

Example: nested structures

- Could have one function to process Addresses

```
void showAddress(Address x) {
   cout << x.street << endl;
   cout << x.city << “, “;
   cout << x.state << “  “;
   cout << x.zip << endl;
}
```

- Call it for different structure types with Address:

```
Student st;
Faculty fac;
GradStudent gs;
//...
showAddress(st.homeAddress);
showAddress(fac.address);
showAddress(gs.campusAddr);
```