Lecture 5

MAC 125

Advanced C++ Programming

Parameters and overloading

Learning Objectives

- Parameters
  - Call-by-value
  - Call-by-reference
  - Mixed parameter-lists
- Overloading and Default Arguments
  - Examples, Rules
- Testing and Debugging Functions
  - assert Macro
  - Stubs, Drivers

Parameters

- Two methods of passing arguments as parameters
- Call-by-value
  - "copy" of value is passed
- Call-by-reference
  - "address of" actual argument is passed

Call-by-Value Parameters

- Copy of actual argument passed
- Considered "local variable" inside function
- If modified, only "local copy" changes
  - Function has no access to "actual argument" from caller
- This is the default method
  - Used in all examples thus far

Call-by-Value Example: Formal Parameter Used as a Local Variable (1 of 3)

Display 4.1 Formal Parameter Used as a Local Variable

```
1   //Law office billing program.
2   #include <iostream>
3   using namespace std;

4   const double RATE = 150.00; //Dollars per quarter hour.

5   double fee(int hoursWorked, int minutesWorked);
6   //Returns the charges for hoursWorked hours and
7   //minutesWorked minutes of legal services.

8   int main( )
9   {
10      int hours, minutes;
11      double bill;
```

Call-by-Value Example: Formal Parameter Used as a Local Variable (2 of 3)

```
12      cout << "Welcome to the law office of\n"
13           << "Dewey, Cheatham, and Howe.\n"
14           << "The law office with a heart.\n"
15           << "Enter the hours and minutes"
16           << " of your consultation:\n";
17      cin >> hours >> minutes;

18      bill = fee(hours, minutes);

19      cout.setf(ios::fixed);
20      cout.setf(ios::showpoint);
21      cout.precision(2);
22      cout << "For " << hours << " hours and " << minutes
23           << " minutes, your bill is $" << bill << endl;

24      return 0;
25  }
```

The value of **minutes** *is not changed by the call to* **fee**.

(continued)

Call-by-Value Example: Formal Parameter Used as a Local Variable (3 of 3)

Display 4.1 Formal Parameter Used as a Local Variable

```
26  double fee(int hoursWorked, int minutesWorked)
27  {
28      int quarterHours;

29      minutesWorked = hoursWorked*60 + minutesWorked;
30      quarterHours = minutesWorked/15;
31      return (quarterHours*RATE);
32  }
```

`minutesWorked` *is a local variable initialized to the value of* `minutes`.

SAMPLE DIALOGUE

```
Welcome to the law office of
Dewey, Cheatham, and Howe.
The law office with a heart.
Enter the hours and minutes of your consultation:
5  46
For 5 hours and 46 minutes, your bill is $3450.00
```

Call-by-Value Pitfall

- Common Mistake:
  - Declaring parameter "again" inside function:

```
double fee(int hoursWorked, int minutesWorked)
{
  int quarterHours;          // local variable
  int minutesWorked          // NO!
}
```

  - Compiler error results
    - "Redefinition error…"
- Value arguments ARE like "local variables"
  - But function gets them "automatically"

Call-By-Reference Parameters

- Used to provide access to caller's actual argument
- Caller's data can be modified by called function!
- Typically used for input function
  - To retrieve data for caller
  - Data is then "given" to caller
- Specified by ampersand, &, after type in formal parameter list

Call-By-Reference Example: Call-by-Reference Parameters (1 of 3)

Display 4.2 Call-by-Reference Parameters

```
1   //Program to demonstrate call-by-reference parameters.
2   #include <iostream>
3   using namespace std;

4   void getNumbers(int& input1, int& input2);
5   //Reads two integers from the keyboard.

6   void swapValues(int& variable1, int& variable2);
7   //Interchanges the values of variable1 and variable2.

8   void showResults(int output1, int output2);
9   //Shows the values of variable1 and variable2, in that order.

10  int main( )
11  {
12      int firstNum, secondNum;

13      getNumbers(firstNum, secondNum);
14      swapValues(firstNum, secondNum);
15      showResults(firstNum, secondNum);
16      return 0;
17  }
```

Call-By-Reference Example: Call-by-Reference Parameters (2 of 3)

```
18  void getNumbers(int& input1, int& input2)
19  {
20      cout << "Enter two integers: ";
21      cin >> input1
22          >> input2;
23  }

24  void swapValues(int& variable1, int& variable2)
25  {
26      int temp;

27      temp = variable1;
28      variable1 = variable2;
29      variable2 = temp;
30  }
31
32  void showResults(int output1, int output2)
33  {
34      cout << "In reverse order the numbers are: "
35           << output1 << " " << output2 << endl;
36  }
```

Call-By-Reference Example: Call-by-Reference Parameters (3 of 3)

Display 4.2 Call-by-Reference Parameters

SAMPLE DIALOGUE

```
Enter two integers: 5 6
In reverse order the numbers are: 6 5
```

Call-By-Reference Details

- What's really passed in?
- A "reference" back to caller's actual argument!
  - Refers to memory location of actual argument
  - Called "address", which is a unique number referring to distinct place in memory

Constant Reference Parameters

- Reference arguments inherently "dangerous"
  - Caller's data can be changed
  - Often this is desired, sometimes not
- To "protect" data, & still pass by reference:
  - Use const keyword
    - void sendConstRef(const int &par1, const int &par2);
    - Makes arguments "read-only" by function
    - No changes allowed inside function body

Parameters and Arguments

- Confusing terms, often used interchangeably
- True meanings:
  - Formal parameters
    - In function declaration and function definition
  - Arguments
    - Used to "fill-in" a formal parameter
    - In function call (argument list)
  - Call-by-value & Call-by-reference
    - Simply the "mechanism" used in plug-in process

Mixed Parameter Lists

- Can combine passing mechanisms
- Parameter lists can include pass-by-value and pass-by-reference parameters
- Order of arguments in list is critical:
  void mixedCall(int & par1, int par2, double & par3);
  - Function call:
    mixedCall(arg1, arg2, arg3);
    - arg1 must be integer type, is passed by reference
    - arg2 must be integer type, is passed by value
    - arg3 must be double type, is passed by reference

Overloading

- Same function name
- Different parameter lists
- Two separate function definitions
- Function "signature"
  - Function name & parameter list
  - Must be "unique" for each function definition
- Allows same task performed on different data

Overloading Example: Average

- Function computes average of 2 numbers:

```
double average(double n1, double n2)
{
 return ((n1 + n2) / 2.0);
}
```

- Now compute average of 3 numbers:

```
double average(double n1, double n2, double n3)
{
 return ((n1 + n2) / 2.0);
}
```

- Same name, two functions

Overloaded Average() Cont'd

- Which function gets called?
- Depends on function call itself:
  - avg = average(5.2, 6.7);
    - Calls "two-parameter average()"
  - avg = average(6.5, 8.5, 4.2);
    - Calls "three-parameter average()"
- Compiler resolves invocation based on signature of function call
  - "Matches" call with appropriate function
  - Each considered separate function

Overloading Resolution

- 1st: Exact Match
  - Looks for exact signature
    - Where no argument conversion required
- 2nd: Compatible Match
  - Looks for "compatible" signature where automatic type conversion is possible:
    - 1st with promotion (e.g., int→double)
      - No loss of data
    - 2nd with demotion (e.g., double→int)
      - Possible loss of data

Overloading Resolution Example

- Given following functions:
  - 1. void f(int n, double m);
    2. void f(double n, int m);
    3. void f(int n, int m);
  - These calls:
    f(98, 99); → Calls #3
    f(5.3, 4); → Calls #2
    f(4.3, 5.2); → Calls ???
- Avoid such confusing overloading

Automatic Type Conversion and Overloading

- Numeric formal parameters typically made "double" type
- Allows for "any" numeric type
  - Any "subordinate" data automatically promoted
    - int → double
    - float → double
- Avoids overloading for different numeric types

Automatic Type Conversion and Overloading Example

- double mpg(double miles, double gallons)
  {
  return (miles/gallons);
  }
- Example function calls:
  - mpgComputed = mpg(5, 20);
    - Converts 5 & 20 to doubles, then passes
  - mpgComputed = mpg(5.8, 20.2);
    - No conversion necessary
  - mpgComputed = mpg(5, 2.4);
    - Converts 5 to 5.0, then passes values to function

Default Arguments

- Allows omitting some arguments
- Specified in function declaration/prototype
  - void showVolume(int length,
    int width = 1,
    int height = 1);
    - Last 2 arguments are defaulted
  - Possible calls:
    - showVolume(2, 4, 6); //All arguments supplied
    - showVolume(3, 5); //height defaulted to 1
    - showVolume(7); //width & height defaulted to 1

Default Arguments Example: Default Arguments (1 of 2)

Display 4.8 Default Arguments

```
1
2   #include <iostream>
3   using namespace std;

4   void showVolume(int length, int width = 1, int height = 1);
5   //Returns the volume of a box.
6   //If no height is given, the height is assumed to be 1.
7   //If neither height nor width is given, both are assumed to be 1.

8   int main( )
9   {
10      showVolume(4, 6, 2);
11      showVolume(4, 6);
12      showVolume(4);

13      return 0;
14  }

15  void showVolume(int length, int width, int height)
```

Default arguments

A default argument should not be given a second time.

Default Arguments Example: Default Arguments (2 of 2)

```
16  {
17      cout << "Volume of a box with \n"
18           << "Length = " << length << ", Width = " << width << endl
19           << "and Height = " << height
20           << " is " << length*width*height << endl;
21  }
```

SAMPLE DIALOGUE

```
Volume of a box with
Length = 4, Width = 6
and Height = 2 is 48
Volume of a box with
Length = 4, Width = 6
and Height = 1 is 24
Volume of a box with
Length = 4, Width = 1
and Height = 1 is 4
```

Testing and Debugging Functions

- Many methods:
  - Lots of cout statements
    - In calls and definitions
    - Used to "trace" execution
  - Compiler Debugger
    - Environment-dependent
  - assert Macro
    - Early termination as needed
  - Stubs and drivers
    - Incremental development

The assert Macro

- Assertion: a true or false statement
- Used to document and check correctness
  - Preconditions & Postconditions
    - Typical assert use: confirm their validity
  - Syntax:
    assert(<assert_condition>);
    - No return value
    - Evaluates assert_condition
    - Terminates if false, continues if true
- Predefined in library <cassert>
  - Macros used similarly as functions

An assert Macro Example

- Given Function Declaration:
  void computeCoin(int coinValue, int& number,
  int& amountLeft);
  //Precondition: 0 < coinValue < 100
  0 <= amountLeft <100
  //Postcondition: number set to max. number
  of coins
- Check precondition:
  - assert ((0 < currentCoin) && (currentCoin < 100)
    && (0 <= currentAmountLeft) && (currentAmountLeft < 100));
  - If precondition not satisfied → condition is false → program execution terminates!

assert Example

```
#include <iostream>
// uncomment to disable assert()
// #define NDEBUG
#include <cassert>
int main() {
assert(2+3==5);
std::cout<< "Execution continues past the first assert\n";
assert(2+3==6);
std::cout<< "Execution continues past the second assert\n";
}
```

Possible output:

```
Execution continues past the first assert
test: test.cc:10: int main(): Assertion `2+3==6' failed.
Aborted
```

An assert Macro Example Cont'd

- Useful in debugging
- Stops execution so problem can be investigated

assert On/Off

- Preprocessor provides means
- #define NDEBUG
  #include <cassert>
- Add "#define" line before #include line
  - Turns OFF all assertions throughout program
- Remove "#define" line (or comment out)
  - Turns assertions back on

Stubs and Drivers

- Separate compilation units
  - Each function designed, coded, tested separately
  - Ensures validity of each unit
  - Divide & Conquer
    - Transforms one big task → smaller, manageable tasks
- But how to test independently?
  - Driver programs

Driver Program Example: Driver Program (1 of 3)

Display 4.9 Driver Program

```
1
2   //Driver program for the function unitPrice.
3   #include <iostream>
4   using namespace std;

5   double unitPrice(int diameter, double price);
6   //Returns the price per square inch of a pizza.
7   //Precondition: The diameter parameter is the diameter of the pizza
8   //in inches. The price parameter is the price of the pizza.

9   int main( )
10  {
11      double diameter, price;
12      char ans;

13      do
14      {
15          cout << "Enter diameter and price:\n";
16          cin >> diameter >> price;
```

Driver Program Example: Driver Program (2 of 3)

```
17          cout << "unit Price is $"
18               << unitPrice(diameter, price) << endl;

19          cout << "Test again? (y/n)";
20          cin >> ans;
21          cout << endl;
22      } while (ans == 'y' || ans == 'Y');

23      return 0;
24  }
25
26  double unitPrice(int diameter, double price)
27  {
28      const double PI = 3.14159;
29      double radius, area;

30      radius = diameter/static_cast<double>(2);
31      area = PI * radius * radius;
32      return (price/area);
33  }
```

(continued)

Driver Program Example: Driver Program (3 of 3)

Display 4.9 Driver Program

SAMPLE DIALOGUE

```
Enter diameter and price:
13 14.75
Unit price is: $0.111126
Test again? (y/n): y

Enter diameter and price:
2 3.15
Unit price is: $1.00268
Test again? (y/n): n
```

Stubs

- Develop incrementally
- Write "big-picture" functions first
  - Low-level functions last
  - "Stub-out" functions until implementation
  - Example:

```
double unitPrice(int diameter, double price)
{
    return (9.99);  // not valid, but noticeably
                    // a "temporary" value
}
```

  - Calls to function will still "work"

Fundamental Testing Rule

- To write "correct" programs
- Minimize errors, "bugs"
- Ensure validity of data
  - Test every function in a program where every other function has already been fully tested and debugged
  - Avoids "error-cascading" & conflicting results

Summary 1

- Formal parameter is placeholder, filled in with actual argument in function call
- Call-by-value parameters are "local copies" in receiving function body
  - Actual argument cannot be modified
- Call-by-reference passes memory address of actual argument
  - Actual argument can be modified
  - Argument MUST be variable, not constant

Summary 2

- Multiple definitions of same function name possible: called overloading
- Default arguments allow function call to "omit" some or all arguments in list
  - If not provided → default values assigned
- assert macro initiates program termination if assertions fail
- Functions should be tested independently
  - As separate compilation units, with drivers