Writing and Understanding C++

- There are language independent skills in programming (C++, Java, ...)
- However, writing programs in any language requires understanding the syntax and semantics of the programming language
  
  ➢ Syntax is similar to rules of spelling and grammar:
    • i before e except after c
    • The relationship between a command and a quote, "this is a fact," or "this is a fact",
  
  ➢ Semantics is what a program (or English sentence) means
    • You ain't nothing but a hound dog.
    • La chienne de ma tante est sur votre tete.

- At first it seems like the syntax is hard to master, but the semantics are much harder
  
  ➢ Natural languages are more forgiving than programming languages.

Toward an Understanding of C++

- Traditional first program, doesn’t convey power of computing but it illustrates basic components of a simple program
  ```cpp
  #include <iostream>
  using namespace std;

  // traditional first program
  int main()
  {
    cout << "Hello world" << endl;
    return 0;
  }
  ```

- This program must be edited/typed, compiled, linked and executed.
- Other languages don’t use compile/link phase, examples?

What’s a namespace?

- In “standard” C++, objects and types are classified as to what namespace they’re in. Hierarchy is good.

  ```cpp
  #include <iostream>

  // traditional first program
  int main()
  {
    std::cout << "Hello world" << std::endl;
    return 0;
  }
  ```

- It’s much simpler to “use” a namespace, in small programs there won’t be any conflicts (and small is fairly big)

Anatomy of a C++ Program

- #include statements make libraries of classes and functions accessible to the program
  
  ➢ Compiler needs access to interface, what the functions look like, but not to implementation
    • This is purpose of header files of source code
  
  ➢ Linker/Loader needs access to implementations
    • This is purpose of Makefile/IDE libraries of object code
    • Helps programmers develop code independently

- Comments make programs readable by humans
  
  ➢ The cost of program maintenance is often far greater than the cost of program development
  ➢ Use comments liberally, but make them meaningful
More C++ Anatomy

- **Programmer-defined functions**
  - Functions are abstractions: help you to reuse ideas and code
  - The square root key on a calculator invokes a function
  - The chorus of a song is a similar abstraction
  - One word, e.g., “chorus”, takes the place of many or represents a concept

- **A program is a collection of functions and classes**
- **Programs may be implemented in more than one file, but there is only one `main` function**
  - Execution of the program begins with `main`
  - The `main` function returns a value to the operating system or environment

Dennis Ritchie

- **Developed C and Unix**
- **Shared 1983 Turing award and National Medal of Science in 1999**

  “We wanted to preserve not just a good environment in which to do programming, but a system around which a fellowship could form”

- **Unix was**
  - Free to Universities
  - Expensive originally
  - Linux precursor?

Execution and Flow Control

- **Execution of C++ programs is organized around statements**
  - A statement executes, it may cause another statement to execute
  - Statements execute sequentially, or as governed by control that repeats a group of statements or selects one of several groups to execute
    - Control statements covered later; for now sequential flow
  - **Syntax determines what’s in a statement, semantics determines construction of program from statements**

- **Output will be part of our programs**
  - `cout` is the output stream, objects are placed on the stream
  - Objects are strings, numbers, many other types

Stream output

- **cout is the standard output stream, use cerr for errors and other streams later. Accessible via `#include<iostream>`**
  - Objects inserted onto stream with insertion operator `<<`
  - Different objects separated by insertion operator `<<`
    ```cpp
    cout << "yadda yadda yadda" << endl;
    cout << " gross = " << 12*12 << endl;
    cout << 5 << " in. = " << 5*2.54 << " cm. " << endl;
    ```
  - **String literals in quotes, other expressions are evaluated before being output.**
    - `endl` is the “end of line” object (IO manipulator)
    - Can also output `\n` or `\t` or `\"` (escape sequences)
More about streams and syntax

- C++ statements are terminated by a semi-colon
  ```cpp
  cout << 3.14159*10*10 << " = area "
  << " of circle with radius = "
  << 10 << ", circ = " << 2*10*3.14159
  << endl;
  ```

- Thinking ahead:
  - Repetition of radius, problems?
  - Repetition of \( \pi \), problems?
  - What’s better, several statements, or one long statement?
  - Evaluating expressions: rules of arithmetic?
  - Differences between 2*3 and 2*3.0?

Functions: Abstractions, shortcuts

- Can you write a program that prints “This rocks” 10^6 times?
  - Only statements permitted are cout << and functions
    - If you know about loops, you have amnesia
  - Naïve solution requires one function and one million print statements, can we improve on this?

- How do you attack this problem?
  - Think of a problem that’s similar, but simpler. Solve it.
  - Generalize solution to the more complex/bigger problem

  - Hello(); vs cout << "Hello World" << endl;

Toward Using Functions

```cpp
#include <iostream>
using namespace std;

int main()
{
  cout << "  ||||||||||||||||  " << endl;
  cout << "  |              |  " << endl;
  cout << "  |    o    o    |  " << endl;
  cout << " _|              |_ " << endl;
  cout << "  |   |______|   |  " << endl;
  cout << "  |              |  " << endl;
  return 0;
}
```

- Prints head, but not as modular as program using functions
  - Harder to modify to draw differently

Programmer-defined Functions

```cpp
#include <iostream>
using namespace std;

int main()
{
  Hair();
  Sides();Eyes(); Ears(); Smile(); Sides();
  return 0;
}
```

- What are advantages of this main over one in which several output statements appear in main.
  - New hair style? Stretched head?
  - Are these advantages?
  - How is width of head determined? Drawbacks? Solutions?
Advantages of Functions

```cpp
#include <iostream>
using namespace std;

// functions appear here

int main()
{
    Hair();
    Sides();
    Eyes(); Ears(); Smile();
    Sides();
    return 0;
}
```

  - Advantages in extending program rather than modifying program.
  - Multiple heads (totem poles)

Totem Functions

```cpp
int main()
{
    Head1();
    Head2();
    Head3();
    return 0;
}
```

- What changed between the two runs of the program?
- Can you write `Headxx()`?
  - Is `Head1` a good name?
  - Does `Headxx` call other functions?
  - Suppose we used graphics instead of `cout <<`?

Parameterized Functions

- A square root function that only returns square root of 2 isn’t very useful
  - \( F = \sqrt{2} \), so 2 is a parameter/argument to the function
- Useful parameter to head-drawing functions?
  - *
  - *
- What about happy birthday printing argument/parameter?

- Functions have parameters, arguments are passed to functions

```cpp
Birthday("Fred"); // sing to fred
Birthday("Ethel"); // sing to ethel
```

Functions and Parameters (continued)

```cpp
#include <iostream>
using namespace std;

void WinBigMoney(string name)
{
    cout << "Hello " << name << " you may have "
         << "$1,000,000" << endl;
    cout << name << " , please call 1-900-IMN-IDiot" << endl;
}

int main()
{
    WinBigMoney("owen"); WinBigMoney("susan");
    WinBigMoney("bill gates");
    return 0;
}
```

- Parameter list provides type and name of parameter
  - Argument type must match parameter type
  - Function’s prototype based on types only, not names
Parameterized Functions for Songs

- On his farm Old MacDonald had a X that says Y
  - pig, oink
  - cow, moo
  ```
  void Verse()
  ```
- Five bottles of Z on a wall, five bottles of Z
  - cola
  - lemonade
  ```
  void Verse()
  ```
- Mama’s going to buy you a X, and if that X Y
  - Mocking bird, don’t sing
  - Looking glass, get’s broke
  ```
  void Verse()
  ```

Calling Functions: where, when, how?

- Some functions are imported from libraries
  - Function prototypes specified in header files, implementations linked later
  - Compiler “sees” prototype before client code calls function
- Some functions are in the same file in which they’re called
  - Function
    - declaration is the prototype only
    - definition includes the implementation
  ```
  void Verse(string name);
  {
    cout << “hi “ << name << endl;
  }
  ```
- Declaration or definition must appear before call
  - Ok to put declaration before, definition after call
  - Ok to put main last, all definitions first (problems?)

Ada Lovelace, 1816-1853

- Daughter of Byron, advocate of work of Charles Babbage, designer of early “computer” (the Analytical Engine)
  - Made Babbage’s work accessible
    “It would weave algebraic patterns the way the Jacquard loom weaved patterns in textiles”
- Tutored in mathematics by Augustus de Morgan
- Marched around the billiard table playing the violin
- Ada is a notable programming language

Program Style

- People who use your program don’t read your code
  - You’ll write programs to match user needs
- People who maintain or modify your program do read code
  - Must be readable, understandable without you next door
  - Use a consistent programming style, adhere to conventions
- Identifiers are names of functions, parameters, (variables, classes, …)
  - Sequence of letters, numbers, underscore ___ characters
  - Cannot begin with a number (we won’t begin with ___)
  - big_head vs. BigHead, we’ll use AlTeRnAtInG format
  - Make identifiers meaningful, not droll and witty