Comp151

Overloading, Construction & Initialization

Introduction

- Our next major topic will be how to initialize new objects using **constructors**. Before doing so we take a short break to introduce another concept that we will need in that discussion, that of function **overloading**. This is a technique that allows the same function name to have many "meanings".

- In ordinary life, you actually use overloading all the time. E.g., `1 + 2` is not the same thing as `1.0 + 2.0` in C++; the + operator is overloaded.

- As another example suppose you want to write one function to compute the average of two numbers and another to compute the average of three numbers:

```
double avg(double n1, double n2) {
    return ((n1 + n2) / 2.0);
}
double avg3(double n1, double n2, double n3) {
    return ((n1 + n2 + n3) / 3.0);
}
```

- In C++, you can use the same name for both functions!

Introduction

- This is legal in C++ (but not in C):

```
double avg(double n1, double n2) {
    return ((n1 + n2) / 2.0);
}
double avg(double n1, double n2, double n3) {
    return ((n1 + n2 + n3) / 3.0);
}
```

Function Overloading

- Overloading allows programmers to use the same name for functions that do *similar* things but with different input arguments.
- In general, both ordinary function names and member function names can be overloaded in C++.

```
 class Word {
 public:
    set( int k ) { frequency = k; }
    set( const char* s ) { str = new char[strlen(s)+1]; strcpy(str,s); }
    set( char c ) { str = new char[2]; str[0] =  c; str[1] = ‘\0’; }
 private:
    int frequency;
    char* str;
};
```

Function Overloading..

- But to speak good C++, don’t abuse overloading. Make sure that your overloaded functions really do *similar* things.

```
class Word {
    …
    set(int k) { frequency = k; }
    set(const char* s) { str = new char[strlen(s)+1]; strcpy(str,s); }
    set(char c) { str = new char[2]; str[0] =  c; str[1] = ‘\0’; }
    set() { cout << str; }    // bad overloading! obscures understanding
} ;
```

- Actually, operators (which are also functions!) are often overloaded. E.g., what is the type of the operands for “+”?

Function Overloading

- As we’ll see, constructors are often overloaded.

```
class Word {
public:
    Word() { };
    Word(const char* s, int k = 1);
    Word(const Word& w);
private:
    int frequency;
    char* str;
};
```

Default Arguments

If a function shows some *default* behaviors most of the time, and some exceptional behaviors only *once in awhile*, specifying default arguments is a *better* option than using overloading.

```
class Word {
    …
public:
    Word( const char* s, int k = 1 ) {
        frequency = k;
        str = new char[strlen(s) + 1]; strcpy(str, s);
    }
};

int main(){
    Word movie(“Brokeback Mountain”);
    Word director(“Ang Lee”, 20);
}
```

In fact, this is <u>also</u> a kind of overloading. (Why?)

Default Arguments..

- There may be more than one default argument.

```
void download( char prog, char os = LINUX, char format = ZIP );
```

- All arguments without default values *must* be declared to the left of default arguments. Thus, the following is an error:

```
void download( char os = LINUX, char prog, char format = ZIP );   // error
int main() { download(LINUX, ‘x’); }        // can’t tell how to interpret this!
```

- An argument can have its default initializer specified only once in a file, usually in the public header file, and not in the function definition. Thus, the following is an error:

```
// word.hpp
class Word {
public:
    Word(const char* s, int k = 1);
    …
}
```

```
// word.cpp
#include “word.hpp”
Word::word(const char* s, int k = 1)
{
    …
}
```

Default Arguments..

- There may be more than one default argument.

```
void download( char prog, char os = LINUX, char format = ZIP );
```

- All arguments without default values *must* be declared to the left of default arguments. Thus, the following is an error:

```
void download( char os = LINUX, char prog, char format = ZIP );   // error
int main() { download(LINUX, 'x'); }        // can't tell how to interpret this!
```

- An argument can have its default initializer specified only once in a file, usually in the public header file, and not in the function definition. Thus, the following is okay:

```
// word.hpp
class Word {
public:
    Word(const char* s, int k = 1);
    …
}
```

```
// word.cpp
#include "word.hpp"
Word::word(const char* s, int k)  // ok
{
    …
}
```

Summary: Overloading

- If you have two or more function definitions for the same function name that is called **overloading**.
- When you overload a function name the different definitions must have different numbers of formal parameters, or some formal parameters of different types.
- The compiler checks each function call and matches it with the particular function definition whose number and type of formal parameters matches.
- The use of the same name to mean different things is called **polymorphism** (Greek for "many forms").
  - Technically, the kind of polymorphism we've just seen is called **ad hoc polymorphism**.
  - We'll see another kind of polymorphism when we discuss templates.

Class Object Initialization

- If ALL data members of the class are <u>public</u>, they can be initialized when the are created as follows:

```
class Word {
public:
    int frequency;
    char* str;
};
```

```
int main() { Word movie = {1, “Brokeback Mountain”}; }
```

Class Object Initialization …

- What happens if some of data members are <u>private</u>?

```
class Word {
public:
    int frequency;
private:
    char* str;
};

int main() { Word movie = {1, “Brokeback Mountain”}; }
```

```
Error: a.cc:8: ‘movie’ must be initialized by
  constructor, not by ‘{ … }’
```

C++ Constructors

- C++ supports a more general mechanism for user-defined initialization of class objects through *constructor member functions*:
  - Word movie;
  - Word director = “Ang Lee”;
  - Word movie = Word(“Brokeback Mountain”);
  - Word *p = **new** Word(“action”, 1);
- Syntactically, a constructor of a class is a special member function having the *same* name as the class.
- A constructor is called **whenever** an object is created, even when the object is only created temporarily, e.g., as a local variable.
- A constructor must **NOT** specify a return type or explicitly returns a value—NOT even the **void** type.

Default Constructor

```
class Word {
public:
    Word() { frequency = 0; str = 0; }
private:
    int frequency;
    char* str;
};

int main(int argc, char* argv[])
{
    Word movie;
}
```

- A *default constructor* is a constructor that is called with **NO** argument: X::X() for class X.
- It is used to initialize an object with user-defined default values.

Compiler Generates a Default Constructor

```
struct Word {
    int frequency;
    char* str;
};

int main(int argc, char* argv[])
{
    Word movie;             // which constructor called?
}
```

- If there are **NO** user-defined constructors, the compiler will generate the default constructor: X::X() for class X for you.
- Word() { } only creates a record with space for an **int** quantity and a **char*** quantity. Their initial values **CANNOT** be trusted.

Compiler Generates a Default Constructor

```
class Word {                // identical meaning to the previous struct
public:
   int frequency;
   char* str;
};

int main(int argc, char* argv[])
{
   Word movie;              // which constructor called?
}
```

- If there are **NO** user-defined constructors, the compiler will generate the default constructor: X::X() for class X for you.
- Word() { } only creates a record with space for an **int** quantity and a **char*** quantity. Their initial values **CANNOT** be trusted.

Default Constructor: Bug

- BUT: only when there are NO user-defined constructors, will the compiler automatically supply the default constructor.

```
class Word {
   …
public:
   Word(const char* s, int k = 0);
};

int main()
{
   Word movie;                          // which constructor?
   Word song("Brokeback Mountain");     // which constructor?
}
```

```
a.cc: 16: no matching function for call to 'Word::Word()'
a.cc: 12: candidates are: Word::Word(const Word &)
a.cc: 7:                  Word::Word(const char*, int)
```

Caution: Weird C++ Syntax

- The default constructor is a function with no parameters so you might think that it should actually be called using

  ```
      Word movie();
  ```

  the same way as any other function without parameters. This in not correct. A default constructor should be called as

  ```
      Word movie;
  ```

  without using the `()`.

Type Conversion Constructor

```
class Word {
    …
public:
    Word(const char* s) {
        frequency = 1;
        str =  new char [strlen(s) + 1]; strcpy(str, s);
    }
};

int main()
{
    Word* p = new Word(“action”);
    Word movie(“Brokeback Mountain”);
    Word director = “Ang Lee”;
}
```

- A constructor accepting a single argument specifies a conversion from its argument type to the type of its class: Word(**const char***) converts from type **const char*** to type Word.

Type Conversion Constructor..

```
class Word {
    …
public:
    Word(const char* s, int k =1) {
        frequency = k;
        str =  new char [strlen(s) + 1]; strcpy(str,s);
     }
};

int main()
{
    Word* p = new Word(“action”);
    Word movie(“Brokeback Mountain”);
    Word director = “Ang Lee”;
}
```

- Notice that if all but **ONE** argument of a constructor have default values, it is still considered a conversion constructor.

Copy Constructor: Example

```
class Word {
public:
   Word(const char* s, int k = 1);
   Word(const Word& w) {
      frequency = w.frequency;
      str = new char[strlen(w.str) + 1];
      strcpy(str, w.str);
   }
};

int main()
{
     Word movie(“Brokeback Mountain”);         // which constructor?
     Word song(movie);                         // which constructor?
}
```

Copy Constructor

- A copy constructor has only ONE argument of the same class
- Syntax: `X(const X&)` for the class X.
- It is called upon:
  - parameter passing to a function (call-by-value)
  - initialization assignment: Word x("Oscars"); Word y = x;
  - value returned by a function:

```
Word Word::to_upper_case()
{
    Word x(*this);
    for (char* p = x.str; *p != '\0'; ++p)
        *p += 'A' - 'a';
    return x;
}
```

Default Copy Constructor

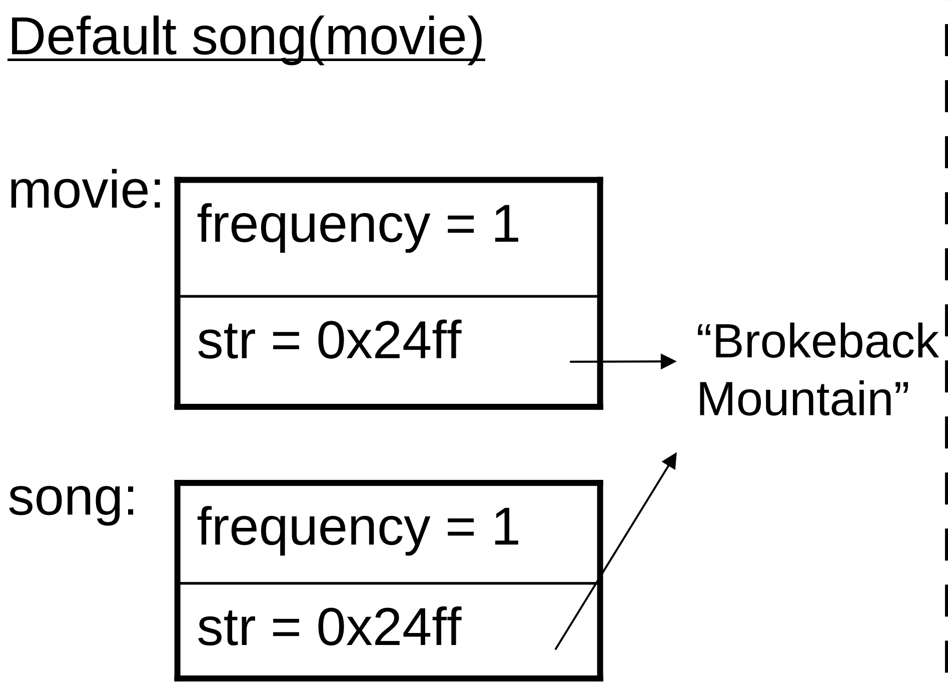
For a class X, if no copy constructor is defined by the user, the compiler will automatically supply: `X(const X&)`

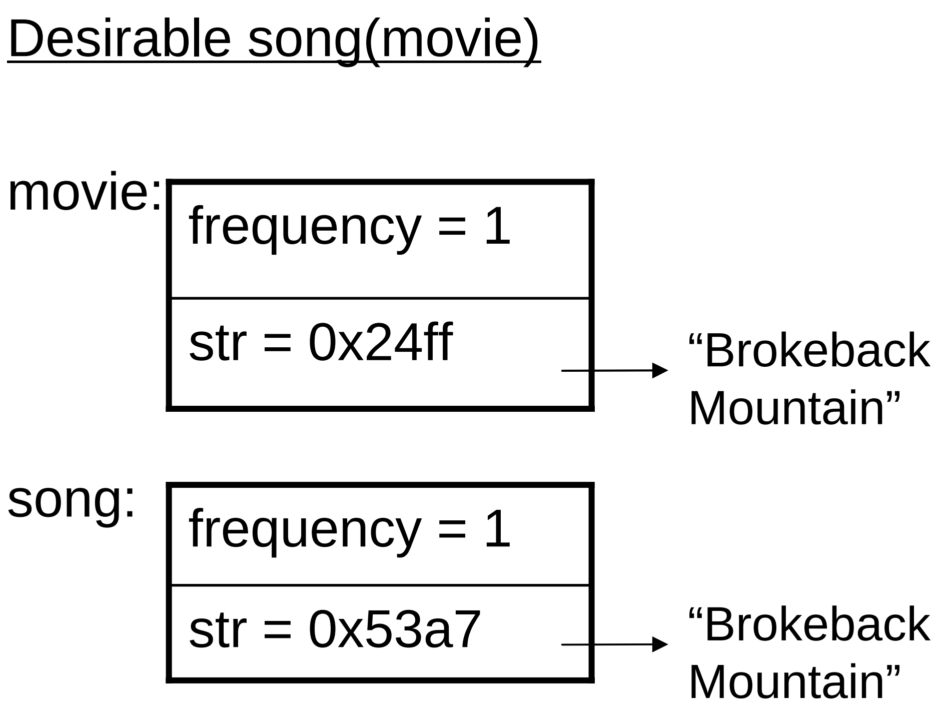
```
class Word {
public:
   Word(const char* s, int k = 0);
};

int main() {
   Word movie("Brokeback Mountain");      // which constructor?
   Word song(movie);                      // which constructor?
   Word song = movie;                     // which constructor?
}
```

=> CAUTION: the compiler-generated default copy constructor does memberwise copy! i.e.,

```
song.frequency = movie.frequency;
song.str = movie.str;
```

Default Copy Constructor
Beware: performs a **memberwise copy** !





Constructor: Quiz

Quiz: How is class initialization done in the following statements?

- Word vowel(“a”);
- Word article = vowel;
- Word movie = “Brokeback Mountain”;

Member Initialization List

Most of the class members may be initialized inside the body of constructor or through member initialization list as follows:

```
class Word {
   int frequency;
   char* str;
public:
   Word(const char* s, int k = 1) : frequency(k) {
      str = new char [strlen(s) + 1]; strcpy( str, s);
   }
};
```

Member Initialization List ..

Member initialization list also works for data members which are user-defined class objects.

```
class WordPair {
    const Word w1;
    Word w2;
public:
    WordPair(const char* s1,  const char* s2) :
                    w1(s1),
                    w2(s2)
    {
    }
};
```

But make sure that the corresponding member constructors exist!

Member Initialization List ..

Member initialization list also works for data members which are user-defined class objects.

```
class WordPair {
    const Word w1;
    Word w2;
public:
    WordPair(const char* s1,  const char* s2) :
                    w2(s2)
    {
        w1 = s1;                  // quiz: what’s the difference here?
    }
};
```

But make sure that the corresponding member constructors exist!

Initialization of `const` or & Members

`const` or reference members can **ONLY** be initialized via the member initialization list. (Why?)

```
class Word2 {
   const char language;
   const Word2& w2;
   int frequency;
   char* str;
public:
   Word2(const char* s1, const Word2& w, int k = 1) :
            language('E'), w2(w), frequency(k) {
      str = new char [strlen(s) + 1]; strcpy( str, s);
   }
};
```

Initialization of `const` or & Members

`const` or reference members can **ONLY** be initialized via the member initialization list. (Why?)

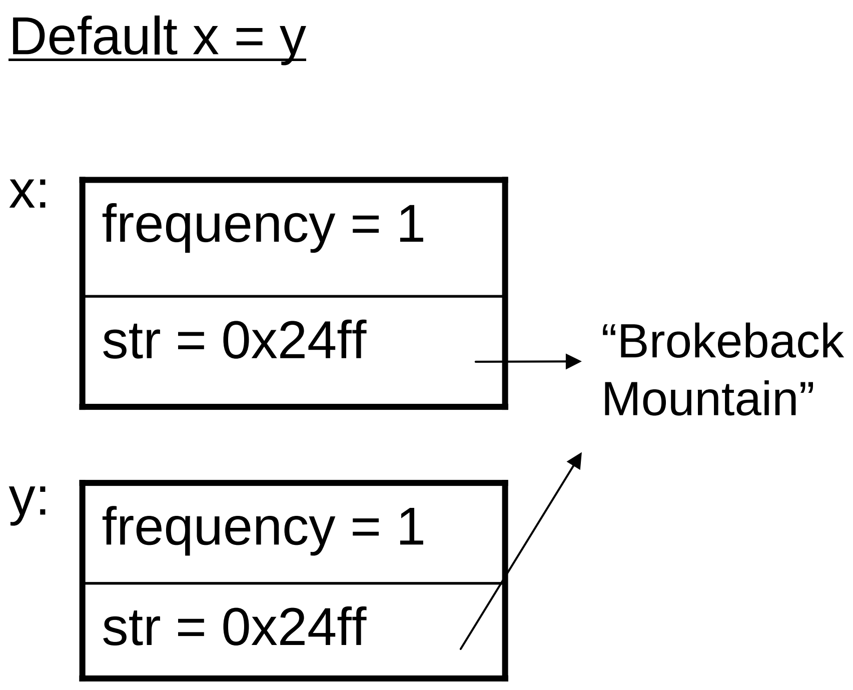
```
class Word2 {
   const char language;
   const Word2& w2;
   int frequency;
   char* str;
public:
   Word2(const char* s1, const Word2& w, int k = 1) :
            language(‘E’), w2(w), frequency(k) {
      str = new char [strlen(s) + 1]; strcpy( str, s);
      language = ‘E’;   // compile-time error
      w2 = ?????
   }
};
```

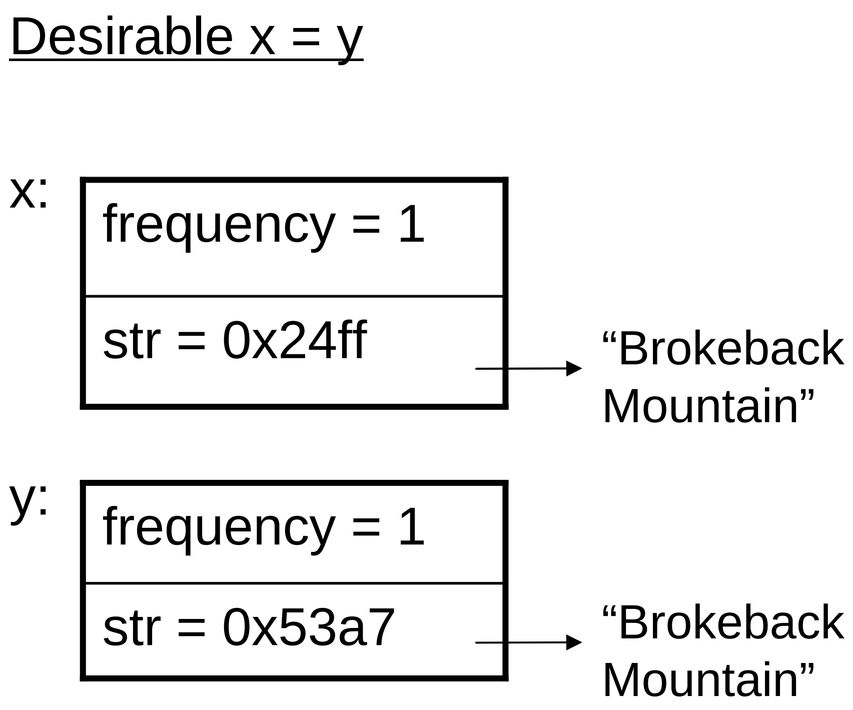
Default Memberwise Assignment

```
Word x("Brokeback Mountain", 1);    // Word(const char*, int) constructor
Word y;                             // Word() constructor
y = x;                              // default memberwise assignment

⇒ y.frequency = x.frequency;
  y.str = x.str;
```

- If an assignment operator function is **NOT** supplied (through operator overloading), the complier will provide the *default* assignment function – *menberwise assignment*
- c.f. the case of copy constructor: if you **DON'T** write your own copy constructor, the compiler will provide the *default* copy constructor—which does memberwise copy;
- Memberwise assignment/copy does **NOT** work whenever memory allocation is required for the class members.

Default Memberwise Assignment ..





Member Class Initialization

Class members should be initialized through member initialization list which calls the appropriate constructors than by assignments.

```
class WordPair
{
    Word word1;
    Word word2;
    WordPair(const char* x, const char* y) : word1(x), word2(y) { }
};
```

⇒ word1/word2 are initialized using the type conversion constructor, Word(**const char***).

```
    WordPair(const char* x, const char* y) { word1 = x; word2 = y; }
```

⇒ error-prone because word1/word2 are initialized by assignment. If there is no user-defined assignment operator function, the default memberwise assignment may **NOT** do what is required.