IOStreams I

Reminder

- Final exam
  - The date for the Final has been decided:
  - Saturday, November 16th
  - 8am – 10am
  - 01-2000

Announcement

- Exam 2
  - Has been moved to Monday October 28th

Project

- Questions?
- Farmer Problem: due Oct 30th

New plan

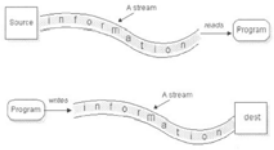
- Today: IOStreams 1
- Thursday: IOStreams 2
- Monday: Exam 2
- Tuesday: IOStreams Leftovers / Exceptions

IOStreams

- Suite of classes for performing I/O in C++
- Reading and Writing:
  - Standard input and output
  - File input and output
  - Input and Output to strings

Streams

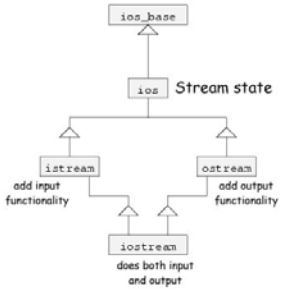
- Like Java, Basic low level mechanism for I/O is the stream
  - Stream is a sequence of bytes



Streams

- Unlike Java, the basic stream in C++ is buffered.
  - Used to increase efficiency
  - When the program writes something, it is put into a buffer in memory.
  - The output doesn't appear on the screen until the buffer is flushed (written)

IOStream class inheritance



`cin` is an istream

`cout` and `cerr` are ostreams

Other classes inherit from these and add I/O to/from a device, string, or memory

IStream

- Extraction
  - Input from an istream object is called extraction.
  - pulling characters out of the stream and into your program
  - `istream` manages format conversion
  - `istream` maintains an error state
    - EOF reached
    - Format errors
    - Serious errors
  - Two types of extraction
    - Formatted / Unformatted

Formatted Extraction

- Done via `operator >>`

```
int i;
cin  >> i;
```

- `operator>>` overloaded for different datatypes.
  - C++ provides operator>> for basic datatypes
  - You can write your own for classes
  - operator>> returns a reference to an istream

```
int i, j, k;
cin  >> i >> j >> k;
```

Formatted Extraction

- Four steps of a formatted extraction
  1. The stream's error state is checked. If it is nonzero (indicating EOF or some error occurred), the remaining steps are skipped
  2. If the extraction is from `cin`, then `cout` is flushed.
  3. Leading whitespace is skipped.
  4. Characters are extracted as needed to obtain the desired value. Whitespace terminates the extraction

Formatted Extraction

- The error state
  - Three error bits
    - `eofbit` – end of file was reached
    - `failbit` – an extraction failed (format error, premature EOF)
    - `badbit` – the stream is bad and probably can't be used any more

Formatted Extraction

- Testing the error state:
  - `cin.good()`
    - Returns true if none of the error bits are set
  - `cin.eof()`
    - Returns true if `eofbit` is set
  - `cin.fail()`
    - Returns true `failbit` or `badbit` is set
  - `cin.bad()`
    - Returns true if `badbit` is set

Formatted Extraction

- Testing the error state.
  - istream overrides some operators to allow an istream to be tested as a boolean:
    - `if( cin )` is the same as `if( !cin.fail() )`
    - `if( !cin )` is the same as `if( cin.fail())`
  - One can also write
    - `if( cin >> i )`
  - Which is equivalent to
    - `cin >> i;`
    - `if( !cin.fail() )`

Formatted Extraction

- About EOF
  - EOF is <u>not</u> set when you've read the last character from the stream
  - it is set when you try to read one character <u>past</u> the end.
  - If EOF is encountered while skipping leading white space, `failbit` is set.

Formatted Extraction

- Example
  - sp sp 123 nl
  - `cin << i;  // all is fine`
  - sp sp 123
  - `cin << i;  // extraction success but eofbit // will be set…next read will fail`

Formatted Extraction

- Must test stream after extraction
  - A good stream does not guarantee more input

```
cin >> i;
while( !cin.fail() ){
    // process the value in i
    cin >> i;
}
```

Or

```
while( cin >> i ){
    // process the value in i
}
```

Formatted Extraction

- But not this:

```
while( cin ){
    cin >> i;
    // process the value in i
}
```

Formatted Extraction

- Extraction of `int` datatypes
  - Rules:
    - If the value begins with 0, it is assumed to be an octal number.
    - If the value begins with 0x or 0X, it is assumed to be a hexadecimal number.
    - Otherwise, the value is assumed to be a decimal number.

Formatted Extraction

- Extraction of `int` datatypes
  - You can force a particular conversion by
    - Setting the format flag in your ios_base (ios:dec, ios:hex, ios:oct)
    - Send a manipulator (dec, hex, oct) to the istream

Formatted Extraction

- Example:
  - will fail for date 09/10/02 (since 09 will be interpreted as octal)

```
char slash;
int month, day, year;
cin >> month >> slash >> day >> slash >> year;
```

  - Use instead:

```
cin >> dec >> month >> slash >> day >> slash >>
  year;
```

Questions?

Unformatted Extraction

- Allows for reading of byte data directly
- Formatted vs. Unformatted
  1. No conversion is done in unformatted extractions: bytes are copied, that is all.
  2. Leading white space is not skipped.
  3. Calls are made to member functions rather than overloaded operators.
     1. get(), getline(), read()

Unformatted Extraction

- Read one character at a time

```
ch = cin.get();
while( ch != EOF ){
     // process the character
     ch = cin.get();
}
```

OR

```
while( cin.get( ch ) ){
    // process the character
}
```

Unformatted Extraction

- Read multiple chars

```
#define BUFLEN ...
char buffer[ BUFLEN ];
// reads up to the first , or until BUFLEN chars
cin.get( buffer, BUFLEN, ',' );
```

OR

```
// get chars a line at a time
while( cin.getline( buffer, BUFLEN ) ){
    // process the line in buffer
}
```

Unformatted Extraction

- Reading raw bytes

```
#define N_VALUES ...
char values[ N_VALUES ];
cin.read( values, N_VALUES ); // bytes are read
  into
                              // char arrays
```

Questions?

OStream

- Insertion
  - Output to an ostream is called an insertion
  - Output to an ostream is called an insertion
  - `ostream` manages format conversion
  - `ostream` maintains an error state but it's not as important as it is with input
  - Two types of extraction
    - Formatted / Unformatted

Formatted Insertion

- Done via `operator <<`

```
int i = 7;
cout << i;
```

- `operator<<` overloaded for different datatypes.
  - C++ provides operator<< for basic datatypes
  - You can write your own for classes
  - operator>> returns a reference to an ostream

```
int i, j, k;
cout  << i << j << k;
```

Formatted Insertion

- Steps of a formatted insertion
  1. The stream's error state is checked. If `failbit` or `badbit` are set, the remaining steps are skipped
  2. The value is converted to the appropriate characters, possibly padded, and then inserted into the stream.

Formatted Insertion

- Format state is more important than with input
  - The format state consists of
    - a number of flags (default: none set)
    - the fill character (default: ' ')
    - Precision (default 6)
    - Mimimum Width(default 0)

Formatted Insertion

- Format flags

```
int flags();         // returns flag settings
int flags (int f);   // replaces current settings
int setf (int f);    // turns on flags
int unsetf (int f);  // turns off flags
```

Formatted Insertion

```
enum fmt_flags {
   boolalpha = 0x0001,
   dec = 0x0002,
   fixed = 0x0004,
   hex = 0x0008,
   internal = 0x0010,
   left = 0x0020,
   oct = 0x0040,
   right = 0x0080,
   scientific = 0x0100,
   showbase = 0x0200,
   showpoint = 0x0400,
   showpos = 0x0800,
   skipws = 0x1000,
   unitbuf = 0x2000,
   uppercase = 0x4000
};
```

Formatted Insertion

- Manipulating format state:

```
char fill ();   // returns the fill char
char fill (char c); // sets the fill char
int precision (); // returns the precision
int precision (int p); // sets the precision
int width (); // returns the width
int width (int w); // sets the width
```

Formatted Insertion

- Manipulators
  - `cout << dec;`
    - Equivalent to `cout.setf( ios::dec );`
  - `cout << oct;`
    - Equivalent to `cout.setf( ios::oct );`
  - `cout << hex;`
    - Equivalent to `cout.setf( ios::hex );`
  - `cout << flush;`
    - Flushes the output buffer
  - `cout << endl;`
    - Ends a line by inserting a newline and flushing the output buffer

Formatted Insertion

- Manipulator
  - `cout << setw( w );`
    - Sets the width to w
  - `cout << setfill( c );`
    - Sets the fill character to c
  - `cout << setprecision( p );`
    - Sets the precision to p
  - `cout << setiosflags( f );`
    - Equivalent to `cout.setf( f );`
  - `cout << resetiosflags( f );`
    - Equivalent to `cout.unsetf( f );`

Unformatted Insertion

- Allows for writing of byte data directly
- For single byte:
  - `cout.put (ch);`
- For array of bytes
  - `cout.write (buffer, len);`

Summary

- IOStreams
  - Istreams
  - Ostreams
- Next time
  - I/O to files
  - I/O to strings
- Questions?