Streams II

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Game Plan

- Recap
- Stream Miscellany
- Stream Internals
- Stringstream
- Tying it all Together
- Stream Manipulators (overflow)
Announcements
Recap
Output Streams

Can only receive data.

- The `std::cout` stream is an example of an output stream.
- All output streams are of type `std::ostream`.

Send data using stream insertion operator: `<<`

Insertions converts data to string and sends to stream.
Input Streams

Can only **give** you data.

- The **std::cin** stream is an example of an input stream.
- All input streams are of type **std::istream**.

Pull out data using stream extraction operator: `>>`

Extraction **gets** data from stream as a string and converts it into the appropriate type.
Reading Data From a File

There are some quirks with extracting a string from a stream.

Reading into a string using `>>` will only read a single word, not the whole line.

To read a whole line, use

```cpp
getline(istream& stream, string& line);
```
Stream Miscellany

Some additional methods for using streams:

```
input.get(ch); // reads one char at a time
input.close(); // closes stream
input.clear(); // resets any fail bits
input.open("filename"); // open stream on file
input.seekg(0); // rewinds stream to start
```
Stream Internals
Buffering

Writing to a console/file is a slow operation.

If the program had to write each character immediately, runtime would significantly slow down.

What can we do?
Buffering

Idea:

Accumulate characters in a temporary buffer/array.

When buffer is full, write out all contents of the buffer to the output device at once.

This process is known as *flushing* the stream
Buffering

Let’s look at this in action:

Stream Buffering

(StreamBuffer.pro)
Buffering

The internal sequence of data stored in a stream is called a buffer.

Istreams use them to store data we haven’t used yet

Ostreams use them to store data they haven’t passed along yet.
Flushing the Buffer

If we want to force the contents of the buffer to their destination, we can flush the stream:

```cpp
stream.flush(ch);       // use by default
stream << std::flush;  // use if you are printing
flush(stream)           // no good reason to use this
stream << std::endl;    // use if you want a newline
```
Flush the Buffer

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Flush the Buffer

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```cpp
stream.flush(ch); // use by default
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stream << std::endl; // use if you want a newline
```

This is equivalent to `stream << "\n" << std::flush;`
Buffering

Let’s look at this in action:

Stream Buffering

(StreamBuffer.pro)
Buffering

Not all streams are buffered (**std::cerr** is an example).

We can get a very real sense of the speed difference:

Stream Buffering Speed

(*BufferSpeed.pro*)
Stream bits

Streams have four bits to give us information about their state:

- **Good bit**: No errors, the stream is good to go
- **EOF bit**: End-of-file was reached during a previous operation
- **Fail bit**: Logical error on a previous operation
- **Bad bit**: Likely unrecoverable error on previous operation
Which bit to use?

1. Read data
2. Check if data is valid, if not break
3. Use data
4. Go back to step 1

```cpp
while(true) {
    stream >> temp;
    if(stream.fail()) break;
    do_something(temp);
}
```
Stream Shortcuts
Chaining `>>` or `<<`

The `<<` and `>>` operators are not magic, they are actually functions!

```cpp
std::cout << "hello";
```

```cpp
operator<<(std::cout, "hello");
```
Chaining `>>` or `<<`

We know functions can return things.

The `<<` and `>> ` operators return the stream passed as their left argument.

This is why this works:

```cpp
std::cout << "hello" << 23 << "world";
```
Chaining $\gg\gg$ or $\ll$

We know functions can return things.

The $\ll$ and $\gg\gg$ operators return the stream passed as their left argument.

This is why this works:

```
(((std::cout << "hello") << 23) << "world");
```
Chaining >> or <<

We know functions can return things.

The << and >> operators return the stream passed as their left argument.

This is why this works:

```cpp
((std::cout << "hello") << 23) << "world");
```
Chaining >> or <<

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The << and >> operators return the stream passed as their left argument.

This is why this works:

```cpp
(((std::cout) << 23) << "world");
```
Chaining `>>` or `<<`

We know functions can return things.

The `<<` and `>>` operators return the stream passed as their left argument.

This is why this works:

```cpp
((std::cout << 23) << "world");
```
Chaining >> or <<

We know functions can return things.

The << and >> operators return the stream passed as their left argument.

This is why this works:

```
((std::cout << 23) << "world");
```
Chaining $\ggg$ or $\lll$

We know functions can return things.

The $\lll$ and $\ggg$ operators return the stream passed as their left argument.

This is why this works:

```cpp
((std::cout) << "world");
```
Chaining >> or <<

We know functions can return things.

The << and >> operators return the stream passed as their left argument.

This is why this works:

```cpp
(std::cout << "world");
```
Which bit to use? - Part II

Let's look at this code again:

```cpp
while (true) {
    stream >> temp;
    if (stream.fail()) break;
    do_something(temp);
}
```
Which bit to use? - Part II

Let’s look at this code again:

```cpp
while(true) {
    stream >> temp;
    if(stream.fail()) break;
    do_something(temp);
}
```

Streams can be converted to bool
Which bit to use? - Part II

Let's look at this code again:

```cpp
while(true) {
    stream >> temp;
    if(!stream) break;
    do_something(temp);
}
```

Streams can be converted to bool
Which bit to use? - Part II

Let's look at this code again:

```c++
while (true) {
    stream >> temp;
    if (!stream) break;  // checks fail or bad bit
    do_something(temp);
}
```
Which bit to use? - Part II

Let’s look at this code again:

```c++
while (true) {
    stream >> temp;
    if (!stream) break;  // checks fail or bad bit
    do_something(temp);
}
```

We know this returns the stream.
while(true) {
    if(!(stream >> temp)) break;
    do_something(temp);
}
Let’s look at this code again:

```java
while(true) {
    if(!(stream >> temp)) break;
    do_something(temp);
}
```

We can simplify the logic.
Which bit to use? - Part II

Let’s look at this code again:

```c
while (stream >> temp) {
    do_something(temp);
}
```
Which bit to use? - Part II

The same principle applies with getline

```c
while (stream >> temp) {
    do_something(temp);
}
while (getline(stream, temp)) {
    do_something(temp);
}
```
stringstream
stringstream

Sometimes we want to be able to treat a string like a stream.

Useful scenarios:

- Converting between data types
- Tokenizing a string
#include <sstream>
std::string line = "137 2.718 Hello";
std::stringstream stream(line);

int myInt;
double myDouble;
std::string myString;
stream >> myInt >> myDouble >> myString;

std::cout << myInt << std::endl;
std::cout << myDouble << std::endl;
std::cout << myString << std::endl;
Tying it Together
Buffering

Let’s write the Stanford simpio library!

Simple IO

(OurSimpIO.pro)
Stream Manipulators
(Overflow)
Stream Manipulator

There are some special keywords that change the behaviour of the stream when inserted.

`std::endl` and `std::flush` are two examples.
Stream Manipulator

Common:
- `endl` inserts a newline and flushes the stream
- `ws` skips all whitespace until it finds another char
- `boolalpha` prints “true” and “false” for bools

Numeric:
- `hex:` prints numbers in hex
- `setprecision:` adjusts the precision numbers print with

Padding:
- `setw` pads output
- `setfill` fills padding with character
Some examples - Padding

```cpp
#include <iomanip>

std::cout << "[" " std::setw(10) " Hi" " ]" " std::endl;
```

Outputs:

```
[   Hi]
```
Some examples - Padding

```cpp
#include <iomanip>

std::cout << "[" << std::left
    << std::setw(10) << "Hi" << "]" << std::endl;
```

Outputs:

```
[Hi     ]
```
Some examples - Padding

```cpp
#include <iomanip>

std::cout << "[" << std::left << std::setfill('-') << std::setw(10) << "Hi" << "]" << std::endl;
```

Outputs:

```
[Hi--------]
```
Some examples - Numeric

```
#include <iomanip>

std::cout << std::hex << 10;  // prints a
std::cout << std::oct << 10;  // prints 12
std::cout << std::dec << 10;  // prints 10
```
Stream Manipulators - Recap

Stream manipulators can be passed into streams to change how they behave.

They have a variety of uses, and if you’d like to format something differently, there’s probably a manipulator for it.

You can find a list of the most common ones at http://www.cplusplus.com/reference/library/manipulators/
Next Time

Sequential Containers