

18.5 — Stream states and input validation

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Stream states

The `ios_base` class contains several state flags that are used to signal various conditions that may occur when using streams:

Flag	Meaning
<code>goodbit</code>	Everything is okay
<code>badbit</code>	Some kind of fatal error occurred (e.g. the program tried to read past the end of a file)
<code>eofbit</code>	The stream has reached the end of a file
<code>failbit</code>	A non-fatal error occurred (eg. the user entered letters when the program was expecting an integer)

Although these flags live in `ios_base`, because `ios` is derived from `ios_base` and `ios` takes less typing than `ios_base`, they are generally accessed through `ios` (eg. as `std::ios::failbit`).

`ios` also provides a number of member functions in order to conveniently access these states:

Member function	Meaning
<code>good()</code>	Returns true if the <code>goodbit</code> is set (the stream is ok)
<code>bad()</code>	Returns true if the <code>badbit</code> is set (a fatal error occurred)
<code>eof()</code>	Returns true if the <code>eofbit</code> is set (the stream is at the end of a file)
<code>fail()</code>	Returns true if the <code>failbit</code> is set (a non-fatal error occurred)
<code>clear()</code>	Clears all flags and restores the stream to the <code>goodbit</code> state
<code>clear(state)</code>	Clears all flags and sets the state flag passed in
<code>rdstate()</code>	Returns the currently set flags
<code>setstate(state)</code>	Sets the state flag passed in

The most commonly dealt with bit is the `failbit`, which is set when the user enters invalid input. For example, consider the following program:

```
1  cout << "Enter your age: ";
2  int nAge;
3  cin >> nAge;
```

Note that this program is expecting the user to enter an integer. However, if the user enters non-numeric data, such as "Alex", `cin` will be unable to extract anything to `nAge`, and the `failbit` will be set.

If an error occurs and a stream is set to anything other than `goodbit`, further stream operations on that stream will be ignored. This condition can be cleared by calling the `clear()` function.

Input validation

Input validation is the process of checking whether the user input meets some set of criteria. Input validation can generally be broken down into two types: string and numeric.

With string validation, we accept all user input as a string, and then accept or reject that string depending on whether it is formatted appropriately. For example, if we ask the user to enter a telephone number, we may want

to ensure the data they enter has ten digits. In most languages (especially scripting languages like Perl and PHP), this is done via regular expressions. However, C++ does not have built-in regular expression support (it's supposedly coming with the next revision of C++), so typically this is done by examining each character of the string to make sure it meets some criteria.

With numerical validation, we are typically concerned with making sure the number the user enters is within a particular range (eg. between 0 and 20). However, unlike with string validation, it's possible for the user to enter things that aren't numbers at all -- and we need to handle these cases too.

To help us out, C++ provides a number of useful functions that we can use to determine whether specific characters are numbers or letters. The following functions live in the `cctype` header:

Function	Meaning
<code>isalnum(int)</code>	Returns non-zero if the parameter is a letter or a digit
<code>isalpha(int)</code>	Returns non-zero if the parameter is a letter
<code>iscntrl(int)</code>	Returns non-zero if the parameter is a control character
<code>isdigit(int)</code>	Returns non-zero if the parameter is a digit
<code>isgraph(int)</code>	Returns non-zero if the parameter is printable character that is not whitespace
<code>isprint(int)</code>	Returns non-zero if the parameter is printable character (including whitespace)
<code>ispunct(int)</code>	Returns non-zero if the parameter is neither alphanumeric nor whitespace
<code>isspace(int)</code>	Returns non-zero if the parameter is whitespace
<code>isxdigit(int)</code>	Returns non-zero if the parameter is a hexadecimal digit (0-9, a-f, A-F)

String validation

Let's do a simple case of string validation by asking the user to enter their name. Our validation criteria will be that the user enters only alphabetic characters or spaces. If anything else is encountered, the input will be rejected.

When it comes to variable length inputs, the best way to validate strings (besides using a regular expression library) is to step through each character of the string and ensure it meets the validation criteria. That's exactly what we'll do here.

```

1  #include <cctype>
2  #include <string>
3  #include <iostream>
4
5  int main()
6  {
7      while (1)
8      {
9          // Get user's name
10         std::cout << "Enter your name: ";
11         std::string strName;
12         std::getline(cin, strName); // get the entire line, including spaces
13
14         bool bRejected = false; // has strName been rejected?
15
16         // Step through each character in the string until we either
17         hit
18         // the end of the string, or we rejected a character
19         for (unsigned int nIndex = 0; nIndex < strName.length() && !bRejected; ++nIndex)
20         {
21             // If the current character is an alpha character, that's fine
22             if (isalpha(strName[nIndex]))
23                 continue;

```

```

24
25     // If it's a space, that's fine too
26     if (strName[nIndex] == ' ')
27         continue;
28
29     // Otherwise we're rejecting this input
30     bRejected = true;
31 }
32
33 // If the input has been accepted, exit the while loop
34 // otherwise we're going to loop again
35 if (!bRejected)
36     break;
37 }

```

Note that this code isn't perfect: the user could say their name was "asf w jweo s di we ao" or some other bit of gibberish, or even worse, just a bunch of spaces. We could address this somewhat by refining our validation criteria to only accept strings that contain at least one character and at most one space.

Now let's take a look at another example where we are going to ask the user to enter their phone number. Unlike a user's name, which is variable-length and where the validation criteria are the same for every character, a phone number is a fixed length but the validation criteria differ depending on the position of the character. Consequently, we are going to take a different approach to validating our phone number input. In this case, we're going to write a function that will check the user's input against a predetermined template to see whether it matches. The template will work as follows:

A # will match any digit in the user input.

A @ will match any alphabetic character in the user input.

A _ will match any whitespace.

A ? will match anything.

Otherwise, the characters in the user input and the template must match exactly.

So, if we ask the function to match the template "(###) ###-####", that means we expect the user to enter a '(' character, three numbers, a ')' character, a space, three numbers, a dash, and four more numbers. If any of these things doesn't match, the input will be rejected.

Here is the code:

```

1  bool InputMatches(string strUserInput, string strTemplate)
2  {
3      if (strTemplate.length() != strUserInput.length())
4          return false;
5
6      // Step through the user input to see if it matches
7      for (unsigned int nIndex=0; nIndex < strTemplate.length(); nIndex++)
8      {
9          switch (strTemplate[nIndex])
10         {
11             case '#': // match a digit
12                 if (!isdigit(strUserInput[nIndex]))
13                     return false;
14                 break;
15             case '_': // match a whitespace
16                 if (!isspace(strUserInput[nIndex]))
17                     return false;
18                 break;
19             case '@': // match a letter
20                 if (!isalpha(strUserInput[nIndex]))
21                     return false;
22                 break;

```

```

23         case '?': // match anything
24             break;
25         default: // match the exact character
26             if (strUserInput[nIndex] != strTemplate[nIndex])
27                 return false;
28     }
29 }
30
31 return true;
32 }
33
34 int main()
35 {
36     string strValue;
37
38     while (1)
39     {
40         cout << "Enter a phone number (###) ###-####: ";
41         getline(cin, strValue); // get the entire line, including spaces
42         if (InputMatches(strValue, "(###) ###-####"))
43             break;
44     }
45
46     cout << "You entered: " << strValue << endl;
47 }

```

Using this function, we can force the user to match our specific format exactly. However, this function is still subject to several constraints: if #, @, _, and ? are valid characters in the user input, this function won't work, because those symbols have been given special meanings. Also, unlike with regular expressions, there is no template symbol that means “a variable number of characters can be entered”. Thus, such a template could not be used to ensure the user enters two words separated by a whitespace, because it can not handle the fact that the words are of variable lengths. For such problems, the non-template approach is generally more appropriate.

Numeric validation

When dealing with numeric input, the obvious way to proceed is to use the extraction operator to extract input to a numeric type. By checking the failbit, we can then tell whether the user entered a number or not.

Let's try this approach:

```

1  int main()
2  {
3      int nAge;
4
5      while (1)
6      {
7          cout << "Enter your age: ";
8          cin >> nAge;
9
10         if (cin.fail()) // no extraction took place
11         {
12             cin.clear(); // reset the state bits back to goodbit so we can use ignore()
13             cin.ignore(32767, '\n'); // clear out the bad input from the stream
14             continue; // try again
15         }
16
17         if (nAge <= 0) // make sure nAge is positive
18             continue;
19
20         break;
21     }
22 }

```

```

23     cout << "You entered: " << nAge << endl;
24 }

```

If the user enters a number, `cin.fail()` will be false, and we will hit the break statement, exiting the loop. If the user enters input starting with a letter, `cin.fail()` will be true, and we will go into the conditional.

However, there's one more case we haven't tested for, and that's when the user enters a string that starts with numbers but then contains letters (eg. "34abcd56"). In this case, the starting numbers (34) will be extracted into `nAge`, the remainder of the string ("abcd56") will be left in the input stream, and the failbit will NOT be set. This causes two potential problems:

- 1) If you want this to be valid input, you now have garbage in your stream.
- 2) If you don't want this to be valid input, it is not rejected (and you have garbage in your stream).

Let's fix the first problem. This is easy:

```

1  int main()
2  {
3      int nAge;
4
5      while (1)
6      {
7          cout << "Enter your age: ";
8          cin >> nAge;
9
10         if (cin.fail()) // no extraction took place
11         {
12             cin.clear(); // reset the state bits back to goodbit so we can use ignore()
13             cin.ignore(32767, '\n'); // clear out the bad input from the stream
14             continue; // try again
15         }
16
17         cin.ignore(32767, '\n'); // clear out any additional input from the stream
18
19         if (nAge <= 0) // make sure nAge is positive
20             continue;
21
22         break;
23     }
24
25     cout << "You entered: " << nAge << endl;
26 }

```

If you don't want such input to be valid, we'll have to do a little extra work. Fortunately, the previous solution gets us half way there. We can use the `gcount()` function to determine how many characters were ignored. If our input was valid, `gcount()` should return 1 (the newline character that was discarded). If it returns more than 1, the user entered something that wasn't extracted properly, and we should ask them for new input. Here's an example of this:

```

1  int main()
2  {
3      int nAge;
4
5      while (1)
6      {
7          cout << "Enter your age: ";
8          cin >> nAge;
9
10         if (cin.fail()) // no extraction took place
11         {
12             cin.clear(); // reset the state bits back to goodbit so we can use ignore()
13             cin.ignore(32767, '\n'); // clear out the bad input from the stream

```

```

14         continue; // try again
15     }
16
17     cin.ignore(32767, '\n'); // clear out any additional input from the stream
18     if (cin.gcount() > 1) // if we cleared out more than one additional character
19         continue; // we'll consider this input to be invalid
20
21     if (nAge <= 0) // make sure nAge is positive
22         continue;
23
24     break;
25 }
26
27 cout << "You entered: " << nAge << endl;
28 }

```

Numeric validation as a string

The above example was quite a bit of work simply to get a simple value! Another way to process numeric input is to read it in as a string, process it as a string, and if it passes the validation, convert it to a numeric type. The following program makes use of that methodology:

```

1  int main()
2  {
3      int nAge;
4
5      while (1)
6      {
7          cout << "Enter your age: ";
8          string strAge;
9          cin >> strAge;
10
11         // Check to make sure each character is a digit
12         bool bValid = true;
13         for (unsigned int nIndex=0; nIndex < strAge.length(); nIndex++)
14             if (!isdigit(strAge[nIndex]))
15             {
16                 bValid = false;
17                 break;
18             }
19         if (!bValid)
20             continue;
21
22         // At this point, we have something that can be converted to a number
23         // So we'll use stringstream to do that conversion
24         stringstream strStream;
25         strStream << strAge;
26         strStream >> nAge;
27
28         if (nAge <= 0) // make sure nAge is positive
29             continue;
30
31         break;
32     }
33
34     cout << "You entered: " << nAge << endl;
35 }

```

Whether this approach is more or less work than straight numeric extraction depends on your validation parameters and restrictions.

As you can see, doing input validation in C++ is a lot of work. Fortunately, many such tasks (eg. doing numeric validation as a string) can be easily turned into functions that can be reused in a wide variety of situations.



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40 comments to 18.5 — Stream states and input validation



Evrik

October 7, 2019 at 9:30 am · Reply

Can I use

```
1 | std::cin.ignore(std::cin.gcount(), '\n')
```

instead of

```
1 | std::cin.ignore(std::numeric_limits<std::streamsize>::max(), '\n')
```

?



nascardriver

October 7, 2019 at 11:58 pm · Reply

No. `std::cin.gcount` returns the number of characters that have been extracted. That's not what you care about, you'd need the number of characters that are left in the input stream. Passing `std::numeric_limits<std::streamsize>::max()` tells `std::cin.ignore` to disable the character count check and ignore everything up to a '\n'.



Maison

September 10, 2019 at 2:53 am · Reply

I feel like this tutorial was rushed. Like me, I see that a lot of people do not understand the string validation tutorial (first example of this current tutorial). Alex can you please make it more clear with input examples because it is not clearly explained as to how the programme is supposed to work.



Nigel Booth

December 20, 2018 at 6:47 am · Reply

Hi Alex, are you missing a main() routine in the first example?