Document number:	P2495R3
Date:	2023-04-13
Project:	Programming Language C++
Audience:	LWG
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Interfacing stringstreams with string_view

Abstract

This paper proposes amending the interface of `basic_[i|o]stringstream` and `basic_stringbuf` to support construction and reinitialization from `basic_string_view`.

Tony Table

Before	Proposed

`const ios_base::openmode mode;`
`const allocator<char> alloc;`
`const string str;`
`//implicitly convertible to string_view`
`const mystring mstr;`
	`const ios_base::openmode mode;`
	`const allocator<char> alloc;`
	`const string str;`
	`//implicitly convertible to string_view`
	`const mystring mstr;`

`stringstream s0{""};` ✔	`stringstream s0{""};` ✔
`stringstream s1{"", alloc};` ✘	`stringstream s1{"", alloc};` ✔
`stringstream s2{"", mode, alloc};` ✘	`stringstream s2{"", mode, alloc};` ✔
`stringstream s3{""sv};` ✘	`stringstream s3{""sv};` ✔
`stringstream s4{""sv, alloc};` ✘	`stringstream s4{""sv, alloc};` ✔
`stringstream s5{""sv, mode, alloc};` ✘	`stringstream s5{""sv, mode, alloc};` ✔
`stringstream s6{""s};` ✔	`stringstream s6{""s};` ✔
`stringstream s7{""s, alloc};` ✔	`stringstream s7{""s, alloc};` ✔
`stringstream s8{""s, mode, alloc};` ✔	`stringstream s8{""s, mode, alloc};` ✔
`stringstream s9{str};` ✔	`stringstream s9{str};` ✔
`stringstream s10{str, alloc};` ✔	`stringstream s10{str, alloc};` ✔
`stringstream s11{str, mode, alloc};` ✔	`stringstream s11{str, mode, alloc};` ✔
`stringstream s12{mstr};` ✘	`stringstream s12{mstr};` ✔
`stringstream s13{mstr, alloc};` ✘	`stringstream s13{mstr, alloc};` ✔
`stringstream s14{mstr, mode, alloc};` ✘	`stringstream s14{mstr, mode, alloc};` ✔
`stringstream s15;`	`stringstream s15;`
`s15.str("");` ✔	`s15.str("");` ✔
`s15.str(""sv);` ✘	`s15.str(""sv);` ✔
`s15.str(""s);` ✔	`s15.str(""s);` ✔
`s15.str(str);` ✔	`s15.str(str);` ✔
`s15.str(mstr);` ✘	`s15.str(mstr);` ✔
`//concerning LWG2946`	`//concerning LWG2946`
`stringstream s16({"abc", 1});` ✔	`stringstream s16({"abc", 1});` ✔
`stringstream s17({"abc", 1}, alloc);` ✘	`stringstream s17({"abc", 1}, alloc);` ✘
`stringstream s18({"abc", 1}, mode, alloc);` ✘	`stringstream s18({"abc", 1}, mode, alloc);` ✘
`stringstream s19;`	`stringstream s19;`
`s19.str({"abc", 1});` ✔	`s19.str({"abc", 1});` ✔

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Revisions

R0: Initial version

R1: Updates after LEWG Review on 2022-08-16:

- Evaluated LWG2946 based on LEWG feedback.
  - Adjusted proposed design & wording accordingly.
  - Removed evaluation of alternative designs as they are either incompatible with LWG2946 or result in an ABI-break.
  - Dropped support for construction from `const CharT *` with an allocator and an optional `openmode`.
- Drive-by fix in [istringstream.cons]: added missing Constraints.
- Added section with frequently asked questions.

R2: Updates after LWG Review on 2023-02-10:

- Per LWG guidance merged wording for proposed constructor overloads per class.
- Using `class` instead of `typename` for wording.
- Fixed style of *Effects*-clauses in wording.
- Upgraded referenced standard draft and use stable references in proposed wording.

R3: Updated after LWG Review on 2023-04-05:

- Modified wording style per LWG guidance.
- Removed redundant constraint "`is_convertible_v<const T&, const CharT *>` is `false`" (originally taken from LWG2946). This change enables constructions with `const CharT *`, an allocator, and an optional `openmode`.

Motivation

[string.view] specifies `basic_string_view`, a vocabulary type template that represents an immutable reference to some string-like object. Unless a string can be moved from source to target, it is generally advisable to pass "immutable stringy inputs" by `basic_string_view`. Doing so obviates the need for multiple overloads and enables support for user-defined types.

[string.streams] specifies the class templates `basic_[i|o]stringstream` and `basic_stringbuf` to represent streams operating on/buffers owning a string. These classes predate the introduction of `basic_string_view` and therefore only support `basic_string` in their interfaces. Partial support for raw strings is provided by implicitly constructing a `basic_string` and then moving it.

This leads to an embarrassing problem when following the aforementioned recommendation: Every `basic_string_view` and user-defined string type must be explicitly converted to a temporary `basic_string` that is then moved into the respective constructor/member function. This paper aims to solve these issues by introducing direct support for `basic_string_view`.

Design space

As all classes in [string.streams] adhere to the following fragment for the context of construction/reinitialization from a string, the potential design is presented in terms of CLASS:

```
template<typename CharT, typename Traits, typename Alloc>
struct CLASS {
  //constructors interfacing with stringy inputs
  explicit CLASS(const basic_string<CharT, Traits, Alloc>&, ios_base::openmode = /*def*/);                    1

  template<typename SAlloc>
  CLASS(const basic_string<CharT, Traits, SAlloc>&, const Alloc&);                                            2

  template<typename SAlloc>
  CLASS(const basic_string<CharT, Traits, SAlloc>&, ios_base::openmode, const Alloc&);                        3

  template<typename SAlloc>
  requires(!std::is_same_v<Alloc, SAlloc>)
  explicit CLASS(const basic_string<CharT, Traits, SAlloc>&, ios_base::openmode = /*def*/);                   4

  explicit CLASS(basic_string<CharT, Traits, Alloc>&&, ios_base::openmode = /*def*/);                         5


  //reinitialization of internal string
  void str(const basic_string<CharT, Traits, Alloc>&);                                                        6

  template<typename SAlloc>
  requires(!std::is_same_v<Alloc, SAlloc>)
  void str(const basic_string<CharT, Traits, SAlloc>&);                                                       7

  void str(basic_string<CharT, Traits, Alloc>&&);                                                             8
```

The constructor and member function overloads can roughly be classified as follows:

No	Description
1	Copying the string.
2 3	Copying the string, input may have different allocator. Invalid for `const CharT *`.
4	Equal to 1 but input has different allocator. Invalid for `const CharT *`.
5	Moving the string, used for `const CharT *`.
6	Copying the string.
7	Equal to 6 but input has different allocator. Invalid for `const CharT *`.
8	Moving the string, used for `const CharT *`.

We propose to add restricted `basic_string_view`-overloads for 1 2 3 6:

```
template<typename T>
static
constexpr
bool is_string_view_like_v{std::is_convertible_v<const T &, basic_string_view<CharT, Traits>>}; //exposition only


//add to existing class definition:
template<typename T>
requires is_string_view_like_v<T>
explicit CLASS(const T&, ios_base::openmode = /*def*/);

template<typename T>
requires is_string_view_like_v<T>
CLASS(const T&, const Alloc&);

template<typename T>
requires is_string_view_like_v<T>
CLASS(const T&, ios_base::openmode, const Alloc&);

template<typename T>
requires is_string_view_like_v<T>
void str(const T&);
```

Impact on the Standard

This proposal is a pure library addition. Existing standard library classes are modified in a non-ABI-breaking way. Overload resolution for singular `const CharT *` arguments changes from constructing a temporary `string` to constructing a `string_view`.

Implementation Experience

The proposed overload set has been implemented on [https://godbolt.org/z/T9P73P9sP] for evaluation[2]. Additionally, the proposed design has been implemented on a fork of the MS-STL [https://github.com/MFHava/STL/tree/P2495].

Frequently Asked Questions

Why is this needed when C++23 includes spanstream?

Whilst there certainly is an overlap between `basic_spanstream` and `basic_stringstream`, fundamental differences in their semantics (ownership & growability) preclude the former to be a drop-in replacement for all conceivable uses of the latter.

Proposed Wording

Wording is relative to [N4944]. Additions are presented like this, removals like ~~this~~ and drafting notes like **this**.

[version.syn]

```
#define __cpp_lib_sstream_from_string_view YYYYMML //also in <sstream>
```
[DRAFTING NOTE: Adjust the placeholder value as needed to denote this proposal's date of adoption.]

[stringbuf]

31.8.2 Class template `basic_stringbuf` **[stringbuf]**

31.8.2.1 General **[stringbuf.general]**

```
namespace std {
  template<class charT, class traits = char_traits<charT>, class Allocator = allocator<charT>>
  class basic_stringbuf : public basic_streambuf<charT, traits> {
…
    // [stringbuf.cons], constructors
…
    template<class SAlloc>
      explicit basic_stringbuf(
        const basic_string<charT, traits, SAlloc>& s,
        ios_base::openmode which = ios_base::in | ios_base::out);
    template<class T>
      explicit basic_stringbuf(const T& t, ios_base::openmode which = ios_base::in | ios_base::out);
    template<class T>
      basic_stringbuf(const T& t, const Allocator& a);
    template<class T>
      basic_stringbuf(const T& t, ios_base::openmode which, const Allocator& a);
    basic_stringbuf(const basic_stringbuf&) = delete;
…
    // [stringbuf.members], getters and setters
…
    void str(basic_string<charT, traits, Allocator>&& s);
    template<class T>
      void str(const T& t);
  protected:
…
  };
}
```

31.8.2.2 Constructors **[stringbuf.cons]**

```
…
template<class SAlloc>
  explicit basic_stringbuf(
    const basic_string<charT, traits, SAlloc>& s,
    ios_base::openmode which = ios_base::in | ios_base::out);
```

8 *Constraints:* `is_same_v<SAlloc, Allocator>` is `false`.

[2] An updated evaluation of all overload sets presented in R0 can be found here: https://godbolt.org/z/esWWr6hTr

Effects: Initializes the base class with basic_streambuf() (***[streambuf.cons]***), mode with which, and buf with s, then calls init_buf_ptrs().

```
template<class T>
  explicit basic_stringbuf(const T& t, ios_base::openmode which = ios_base::in | ios_base::out);
template<class T>
  basic_stringbuf(const T& t, const Allocator& a);
template<class T>
  basic_stringbuf(const T& t, ios_base::openmode which, const Allocator& a);
```

Let which be ios_base::in | ios_base::out for the overload with no parameter which, and a be Allocator() for the overload with no parameter a.

Constraints: is_convertible_v<const T&, basic_string_view<charT, traits>> is true.

Effects: Creates a variable, sv, as if by basic_string_view<charT, traits> sv = t, then value-initializes the base class, initializes mode with which, and direct-non-list-initializes buf with sv, a, then calls init_buf_ptrs().

```
basic_stringbuf(basic_stringbuf&& rhs);
basic_stringbuf(basic_stringbuf&& rhs, const Allocator& a);
```

[DRAFTING NOTE: Renumber remaining constructors.]

31.8.2.4 Member functions **[stringbuf.members]**

…

```
void str(basic_string<charT, traits, Allocator>&& s);
```

Effects: Equivalent to:

```
buf = std::move(s);
init_buf_ptrs();
```

```
template<class T>
  void str(const T& t);
```

Constraints: is_convertible_v<const T&, basic_string_view<charT, traits>> is true.

Effects: Equivalent to:

```
basic_string_view<charT, traits> sv = t;
buf = sv;
init_buf_ptrs();
```

31.8.2.5 Overridden virtual functions **[stringbuf.virtuals]**

[istringstream]

31.8.3 Class template basic_istringstream **[istringstream]**

31.8.3.1 General **[istringstream.general]**

```
namespace std {
  template<class charT, class traits = char_traits<charT>, class Allocator = allocator<charT>>
  class basic_istringstream : public basic_istream<charT, traits> {
…
    // [istringstream.cons], constructors
…
    template<class SAlloc>
      explicit basic_istringstream(
        const basic_string<charT, traits, SAlloc>& s,
        ios_base::openmode which = ios_base::in);
    template<class T>
      explicit basic_istringstream(const T& t, ios_base::openmode which = ios_base::in);
    template<class T>
      basic_istringstream(const T& t, const Allocator& a);
    template<class T>
      basic_istringstream(const T& t, ios_base::openmode which, const Allocator& a);
    basic_istringstream(const basic_istringstream&) = delete;
…
    // [istringstream.members], members
…
    void str(basic_string<charT, traits, Allocator>&& s);
    template<class T>
      void str(const T& t);
  private:
…
  };
}
```

31.8.3.2 Constructors **[istringstream.cons]**

…

```
template<class SAlloc>
  explicit basic_istringstream(
    const basic_string<charT, traits, SAlloc>& s,
    ios_base::openmode which = ios_base::in);
```

Constraints: is_same_v<SAlloc, Allocator> is false.

[DRAFTING NOTE: Drive-by fix, this adds a missing constraint present in stringstream and ostringstream.]

Effects: Initializes the base class with basic_istream<charT, traits>(addressof(sb)) (***[istream]***), and sb with basic_stringbuf<charT, traits, Allocator>(s, which | ios_base::in) (***[stringbuf.cons]***).

```
template<class T>
  explicit basic_istringstream(const T& t, ios_base::openmode which = ios_base::in);
template<class T>
  basic_istringstream(const T& t, const Allocator& a);
template<class T>
```

```
    basic_istringstream(const T& t, ios_base::openmode which, const Allocator& a);
8     Let which be ios_base::in for the overload with no parameter which, and a be Allocator() for the overload with no parameter a.
9     Constraints: is_convertible_v<const T&, basic_string_view<charT, traits>> is true.
10    Effects: Initializes the base class with addressof(sb), and direct-non-list-initializes sb with t, which | ios_base::in, a.

  basic_istringstream(basic_istringstream&& rhs);
    [DRAFTING NOTE: Renumber remaining constructors.]
```

31.8.3.4 Member functions **[istringstream.members]**

```
  …
  void str(basic_string<charT, traits, Allocator>&& s);
8   Effects: Equivalent to: rdbuf()->str(std::move(s));

  template<class T>
    void str(const T& t);
9     Constraints: is_convertible_v<const T&, basic_string_view<charT, traits>> is true.
10    Effects: Equivalent to rdbuf()->str(t).
```

[ostringstream]

31.8.4 Class template `basic_ostringstream` **[ostringstream]**

31.8.4.1 General **[ostringstream.general]**

```
  namespace std {
    template<class charT, class traits = char_traits<charT>, class Allocator = allocator<charT>>
    class basic_ostringstream : public basic_ostream<charT, traits> {
  …
      // [ostringstream.cons], constructors
  …
      template<class SAlloc>
        explicit basic_ostringstream(
          const basic_string<charT, traits, SAlloc>& s,
          ios_base::openmode which = ios_base::out);
      template<class T>
        explicit basic_ostringstream(const T& t, ios_base::openmode which = ios_base::out);
      template<class T>
        basic_ostringstream(const T& t, const Allocator& a);
      template<class T>
        basic_ostringstream(const T& t, ios_base::openmode which, const Allocator& a);
      basic_ostringstream(const basic_ostringstream&) = delete;
  …
      // [ostringstream.members], members
  …
      void str(basic_string<charT, traits, Allocator>&& s);
      template<class T>
        void str(const T& t);
    private:
  …
    };
  }
```

31.8.4.2 Constructors **[ostringstream.cons]**

```
  …
  template<class SAlloc>
    explicit basic_ostringstream(
      const basic_string<charT, traits, SAlloc>& s,
      ios_base::openmode which = ios_base::out);
6   Constraints: is_same_v<SAlloc, Allocator> is false.
7   Effects: Initializes the base class with basic_ostream<charT, traits>(addressof(sb)) (***[ostream]***), and sb with basic_stringbuf<charT, traits, Allocator>(s, which | ios_base::out) (***[stringbuf.cons]***).

  template<class T>
    explicit basic_ostringstream(const T& t, ios_base::openmode which = ios_base::out);
  template<class T>
    basic_ostringstream(const T& t, const Allocator& a);
  template<class T>
    basic_ostringstream(const T& t, ios_base::openmode which, const Allocator& a);
8   Let which be ios_base::out for the overload with no parameter which, and a be Allocator() for the overload with no parameter a.
9   Constraints: is_convertible_v<const T&, basic_string_view<charT, traits>> is true.
10  Effects: Initializes the base class with addressof(sb), and direct-non-list-initializes sb with t, which | ios_base::out, a.

  basic_ostringstream(basic_ostringstream&& rhs);
    [DRAFTING NOTE: Renumber remaining constructors.]
```

31.8.4.4 Member functions **[ostringstream.members]**

```
  …
  void str(basic_string<charT, traits, Allocator>&& s);
8   Effects: Equivalent to: rdbuf()->str(std::move(s));

  template<class T>
    void str(const T& t);
9     Constraints: is_convertible_v<const T&, basic_string_view<charT, traits>> is true.
10    Effects: Equivalent to rdbuf()->str(t).
```

[stringstream]

31.8.5 Class template `basic_stringstream` **[stringstream]**

31.8.5.1 General **[stringstream.general]**

```
namespace std {
  template<class charT, class traits = char_traits<charT>, class Allocator = allocator<charT>>
  class basic_stringstream : public basic_iostream<charT, traits> {
…
    // [stringstream.cons], constructors
…
    template<class SAlloc>
      explicit basic_stringstream(
        const basic_string<charT, traits, SAlloc>& s,
        ios_base::openmode which = ios_base::out | ios_base::in);
    template<class T>
      explicit basic_stringstream(const T& t, ios_base::openmode which = ios_base::out | ios_base::in);
    template<class T>
      basic_stringstream(const T& t, const Allocator& a);
    template<class T>
      basic_stringstream(const T& t, ios_base::openmode which, const Allocator& a);
    basic_stringstream(const basic_stringstream&) = delete;
…
    // [stringstream.members], members
…
    void str(basic_string<charT, traits, Allocator>&& s);
    template<class T>
      void str(const T& t);
  private:
…
  }
};
```

31.8.5.2 Constructors **[stringstream.cons]**

```
…
template<class SAlloc>
  explicit basic_stringstream(
    const basic_string<charT, traits, SAlloc>& s,
    ios_base::openmode which = ios_base::out | ios_base::in);
```

6 *Constraints:* `is_same_v<SAlloc, Allocator>` is `false`.

7 *Effects*: Initializes the base class with `basic_iostream<charT, traits>(addressof(sb))` (***[iostream.cons]***), and `sb` with `basic_stringbuf<charT, traits, Allocator>(s, which)` (***[stringbuf.cons]***).

```
template<class T>
  explicit basic_stringstream(const T& t, ios_base::openmode which = ios_base::out | ios_base::in);
template<class T>
  basic_stringstream(const T& t, const Allocator& a);
template<class T>
  basic_stringstream(const T& t, ios_base::openmode which, const Allocator& a);
```

8 Let `which` be `ios_base::out | ios_base::in` for the overload with no parameter `which`, and `a` be `Allocator()` for the overload with no parameter `a`.

9 *Constraints*: `is_convertible_v<const T&, basic_string_view<charT, traits>>` is `true`.

10 *Effects:* Initializes the base class with `addressof(sb)`, and direct-non-list-initializes `sb` with `t, which, a`.

```
basic_stringstream(basic_stringstream&& rhs);
```

[DRAFTING NOTE: Renumber remaining constructors.]

31.8.5.4 Member functions **[stringstream.members]**

```
…
void str(basic_string<charT, traits, Allocator>&& s);
```

8 *Effects*: Equivalent to: `rdbuf()->str(std::move(s));`

```
template<class T>
  void str(const T& t);
```

9 *Constraints*: `is_convertible_v<const T&, basic_string_view<charT, traits>>` is `true`.

10 *Effects*: Equivalent to `rdbuf()->str(t)`.

Acknowledgements

Thanks to RISC Software GmbH for supporting this work. Thanks to Peter Kulczycki and Bernhard Manfred Gruber for proof reading and discussions.