

p0448r0 - A stringstream replacement using `span<charT>` as buffer

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2016-10-14

Document Number: p0448r0	(N2065 done right?)
Date:	2016-10-14
Project:	Programming Language C++
Audience:	LWG/LEWG

1 History

Streams have been the oldest part of the C++ standard library and especially `stringstream`s that can use pre-allocated buffers have been deprecated for a long time now, waiting for a replacement. `p0407` and `p0408` provide the efficient access to the underlying buffer for `stringstreams` that `stringstream` provided solving half of the problem that `stringstream`s provide a solution for. The other half is using a fixed size pre-allocated buffer, e.g., allocated on the stack, that is used as the stream buffers internal storage.

A combination of external-fixed and internal-growing buffer allocation that `stringstreambuf` provides is IMHO a doomed approach and very hard to use right.

There had been a proposal for the pre-allocated external memory buffer streams in N2065 but that went nowhere. Today, with `span<T>` we actually have a library type representing such buffers views we can use for specifying (and implementing) such streams. They can be used in areas where dynamic (re-)allocation of `stringstreams` is not acceptable but the burden of caring for a pre-existing buffer during the lifetime of the stream is manageable.

2 Introduction

This paper proposes a class template `basic_spanbuf` and the corresponding stream class templates to enable the use of streams on externally provided memory buffers. No ownership or re-allocation support is given. For those features we have string-based streams.

3 Acknowledgements

- Thanks to those ISO C++ meeting members attending the Oulu meeting encouraging me to write this proposal. I believe Neil and Pablo have been among them, but can't remember who else.
- Thanks go to Jonathan Wakely who pointed the problem of `stringstream` out to me and to Neil Macintosh to provide the span library type specification.
- Thanks to Felix Morgner for proofreading.

4 Motivation

To finally get rid of the deprecated `stringstream` in the C++ standard we need a replacement. p0407/p0408 provide one for one half of the needs for `stringstream`. This paper provides one for the second half: fixed sized buffers.

[*Example:* reading input from a fixed pre-arranged character buffer:

```
char input[] = "10 20 30";
ispanstream is{span<char>{input}};
int i;
is >> i;
ASSERT_EQUAL(10,i);
is >> i ;
ASSERT_EQUAL(20,i);
is >> i;
ASSERT_EQUAL(30,i);
is >>i;
ASSERT(!is);
```

— *end example*] [*Example:* writing to a fixed pre-arranged character buffer:

```
char output[30]{}; // zero-initialize array
ospanstream os{span<char>{output}};
os << 10 << 20 << 30 ;
auto const sp = os.span();
ASSERT_EQUAL(6,sp.size());
ASSERT_EQUAL("102030",std::string(sp.data(),sp.size()));
ASSERT_EQUAL(static_cast<void*>(output),sp.data()); // no copying of underlying data!
ASSERT_EQUAL("102030",output); // initialization guaranteed NUL termination
```

— *end example*]

5 Impact on the Standard

This is an extension to the standard library to enable deletion of the deprecated `stringstream` classes by providing `basic_spanbuf`, `basic_spanstream`, `basic_ispanstream`, and `basic_`

`ospanstream` class templates that take an object of type `span<charT>` which provides an external buffer to be used by the stream.

6 Design Decisions

6.1 General Principles

6.2 Open Issues to be Discussed by LEWG / LWG

- Should arbitrary types as template arguments to `span` be allowed to provide the underlying buffer by using the `byte` sequence representation `span` provides. (I do not think so, but someone might have a usecase.)
- Should the `basic_spanbuf` be copy-able? It doesn't own any resources, so copying like with handles or `span` might be fine.

7 Technical Specifications

Insert a new section 27.x in chapter 27 after section 27.8 [string.streams]

7.1 27.x Span-based Streams [span.streams]

This section introduces a stream interface for user-provided fixed-size buffers.

7.1.1 27.x.1 Overview [span.streams.overview]

The header `<spanstream>` defines four class templates and eight types that associate stream buffers with objects of class `span` as described in [span].

```
namespace std {
namespace experimental {
    template <class charT, class traits = char_traits<charT> >
        class basic_spanbuf;
    typedef basic_spanbuf<char>          spanbuf;
    typedef basic_spanbuf<wchar_t>      wspanbuf;
    template <class charT, class traits = char_traits<charT> >
        class basic_ispanstream;
    typedef basic_ispanstream<char>     ispanstream;
    typedef basic_ispanstream<wchar_t> wispanstream;
    template <class charT, class traits = char_traits<charT> >
        class basic_ospanstream;
    typedef basic_ospanstream<char>     ospanstream;
    typedef basic_ospanstream<wchar_t> wospanstream;

```

```

template <class charT, class traits = char_traits<charT> >
    class basic_spanstream;
typedef basic_spanstream<char>      spanstream;
typedef basic_spanstream<wchar_t>  wspanstream;
}}

```

7.2 27.x.2 Class template basic_spanbuf [spanbuf]

```

namespace std {
    template <class charT, class traits = char_traits<charT> >
    class basic_spanbuf
        : public basic_streambuf<charT, traits> {
    public:
        using char_type      = charT;
        using int_type       = typename traits::int_type;
        using pos_type       = typename traits::pos_type;
        using off_type       = typename traits::off_type;
        using traits_type    = traits;

        // ??, constructors:
        template <ptrdiff_t Extent>
        explicit basic_spanbuf(
            span<charT, Extent> span,
            ios_base::openmode which = ios_base::in | ios_base::out);
        basic_spanbuf(const basic_spanbuf& rhs) = delete;
        basic_spanbuf(basic_spanbuf&& rhs) noexcept;

        // ??, assign and swap:
        basic_spanbuf& operator=(const basic_spanbuf& rhs) = delete;
        basic_spanbuf& operator=(basic_spanbuf&& rhs) noexcept;
        void swap(basic_spanbuf& rhs) noexcept;

        // ??, get and set:
        span<charT> span() const noexcept;
        void span(span<charT> s) noexcept;

    protected:
        // ??, overridden virtual functions:
        int_type underflow() override;
        int_type pbackfail(int_type c = traits::eof()) override;
        int_type overflow (int_type c = traits::eof()) override;
        basic_streambuf<charT, traits>* setbuf(charT*, streamsize) override;

        pos_type seekoff(off_type off, ios_base::seekdir way,
            ios_base::openmode which
                = ios_base::in | ios_base::out) override;
        pos_type seekpos(pos_type sp,

```

```

        ios_base::openmode which
        = ios_base::in | ios_base::out) override;

private:
    ios_base::openmode mode; // exposition only
};

template <class charT, class traits>
    void swap(basic_spanbuf<charT, traits>& x,
              basic_spanbuf<charT, traits>& y) noexcept;
}

```

- 1 The class `basic_spanbuf` is derived from `basic_streambuf` to associate possibly the input sequence and possibly the output sequence with a sequence of arbitrary *characters*. The sequence is provided by an object of class `span<charT>`.
- 2 For the sake of exposition, the maintained data is presented here as:
 - `ios_base::openmode mode`, has `in` set if the input sequence can be read, and `out` set if the output sequence can be written.

7.3 27.x.2.1 `basic_spanbuf` constructors [spanbuf.cons]

```

template <ptrdiff_t Extent>
explicit basic_spanbuf(
    basic_span<charT, Extent> s,
    ios_base::openmode which = ios_base::in | ios_base::out);

```

- 1 *Effects:* Constructs an object of class `basic_spanbuf`, initializing the base class with `basic_streambuf()` (??), and initializing `mode` with `which`. Initializes the internal pointers as if calling `span(s)`.

```
basic_spanbuf(basic_spanbuf&& rhs) noexcept;
```

- 2 *Effects:* Move constructs from the rvalue `rhs`. Both `basic_spanbuf` objects share the same underlying `span`. The sequence pointers in `*this` (`eback()`, `gptr()`, `egptr()`, `pbase()`, `pptr()`, `epptr()`) obtain the values which `rhs` had. The open-mode, locale and any other state of `rhs` is also copied.

- 3 *Postconditions:* Let `rhs_p` refer to the state of `rhs` just prior to this construction.

- `span() == rhs_p.span()`
- `eback() == rhs_p.eback()`

- `gptr() == rhs_p.gptr()`
- `egptr() == rhs_p.egptr()`
- `pbase() == rhs_p.pbase()`
- `pptr() == rhs_p.pptr()`
- `epptr() == rhs_p.epptr()`

7.3.1 27.x.2.2 Assign and swap [`spanbuf.assign`]

```
basic_spanbuf& operator=(basic_spanbuf&& rhs) noexcept;
```

1 *Effects:* After the move assignment `*this` has the observable state it would have had if it had been move constructed from `rhs` (see ??).

2 *Returns:* `*this`.

```
void swap(basic_spanbuf& rhs) noexcept;
```

3 *Effects:* Exchanges the state of `*this` and `rhs`.

```
template <class charT, class traits, class Allocator>
void swap(basic_spanbuf<charT, traits>& x,
         basic_spanbuf<charT, traits>& y) noexcept;
```

4 *Effects:* As if by `x.swap(y)`.

7.3.2 27.x.2.3 Member functions [`spanbuf.members`]

```
span<charT> span() const;
```

1 *Returns:* A `span` object representing the `basic_spanbuf` underlying character sequence. If the `basic_spanbuf` was created only in output mode, the resultant `span` represents the character sequence in the range `[pbase(), pptr())`, otherwise in the range `[eback(), egptr())`. [*Note:* In contrast to `basic_stringbuf` the underlying sequence can never grow and will not be owned. An owning copy can be obtained by converting the result to `basic_string<charT>`. — *end note*]

```
template<ptrdiff_t Extent>
void span(span<charT, Extent> s);
```

2 *Effects:* Initializes the `basic_spanbuf` underlying character sequence with `s` and initializes the input and output sequences according to `mode`.

3 *Postconditions:* If `mode & ios_base::out` is true, `pbase()` points to the first underlying character and `eptr() >= pbase() + s.size()` holds; in addition, if `mode & ios_base::ate` is true, `pptr() == pbase() + s.size()` holds, otherwise `pptr() == pbase()` is true. If `mode & ios_base::in` is true, `eback()` points to the first underlying character, and both `gptr() == eback()` and `egptr() == eback() + s.size()` hold.

[*Note:* Using append mode does not make sense for `span`-based streams. — *end note*]

7.3.3 27.x.2.4 Overridden virtual functions [`spanbuf.virtuals`]

1 [*Note:* Since the underlying buffer is of fixed size, neither `overflow`, `underflow` or `pbackfail` can provide useful behavior. — *end note*]

```
int_type underflow() override;
```

2 *Returns:* `traits::eof()`.

```
int_type pbackfail(int_type c = traits::eof()) override;
```

3 *Returns:* `traits::eof()`.

```
int_type overflow(int_type c = traits::eof()) override;
```

4 *Returns:* `traits::eof()`.

```
pos_type seekoff(off_type off, ios_base::seekdir way,
                ios_base::openmode which
                = ios_base::in | ios_base::out) override;
```

5 *Effects:* Alters the stream position within one of the controlled sequences, if possible, as indicated in Table ??.

6 For a sequence to be positioned, if its next pointer (either `gptr()` or `pptr()`) is a null pointer and the new offset `newoff` is nonzero, the positioning operation fails. Otherwise, the function determines `newoff` as indicated in Table ??.

- 7 If $(\text{newoff} + \text{off}) < 0$, or if $\text{newoff} + \text{off}$ refers to an uninitialized character outside the span (as defined in ?? paragraph 1), the positioning operation fails. Otherwise, the function assigns $\text{xbeg} + \text{newoff} + \text{off}$ to the next pointer xnext .
- 8 *Returns:* `pos_type(newoff)`, constructed from the resultant offset `newoff` (of type `off_type`), that stores the resultant stream position, if possible. If the positioning operation fails, or if the constructed object cannot represent the resultant stream position, the return value is `pos_type(off_type(-1))`.

```
pos_type seekpos(pos_type sp,
                ios_base::openmode which
                = ios_base::in | ios_base::out) override;
```

- 9 *Effects:* Equivalent to `seekoff(off_type(sp), ios_base::beg, which)`.
- 10 *Returns:* `sp` to indicate success, or `pos_type(off_type(-1))` to indicate failure.

```
basic_streambuf<charT, traits>* setbuf(charT* s, streamsize n);
```

- 11 *Effects:* If `s` and `n` denote a non-empty span `this->span(span<charT>(s,n))`;
- 12 *Returns:* `this`.

7.4 27.x.3 Class template `basic_ispanstream` [`ispanstream`]

```
namespace std {
    template <class charT, class traits = char_traits<charT>>
    class basic_ispanstream
        : public basic_istream<charT, traits> {
    public:
        using char_type      = charT;
        using int_type       = typename traits::int_type;
        using pos_type       = typename traits::pos_type;
        using off_type       = typename traits::off_type;
        using traits_type    = traits;

        // 7.4.1, constructors:
        template <ptrdiff_t Extent>
        explicit basic_ispanstream(
            span<charT, Extent> span,
            ios_base::openmode which = ios_base::in);
        basic_ispanstream(const basic_ispanstream& rhs) = delete;
        basic_ispanstream(basic_ispanstream&& rhs) noexcept;
```

```

// 7.4.2, assign and swap:
basic_ispanstream& operator=(const basic_ispanstream& rhs) = delete;
basic_ispanstream& operator=(basic_ispanstream&& rhs) noexcept;
void swap(basic_ispanstream& rhs) noexcept;

// 7.4.3, members:
basic_spanbuf<charT, traits>* rdbuf() const noexcept;

span<charT> span() const noexcept;
    template<ptrdiff_t Extent>
void span(span<charT> s) noexcept;
private:
    basic_spanbuf<charT, traits> sb; // exposition only
};

template <class charT, class traits>
void swap(basic_ispanstream<charT, traits>& x,
          basic_ispanstream<charT, traits>& y) noexcept;
}

```

- ¹ The class `basic_ispanstream<charT, traits>` supports reading objects of class `span<charT, traits>`. It uses a `basic_spanbuf<charT, traits>` object to control the associated span. For the sake of exposition, the maintained data is presented here as:
- `sb`, the spanbuf object.

7.4.1 27.x.3.1 `basic_ispanstream` constructors [ispanstream.cons]

```

template <ptrdiff_t Extent>
explicit basic_ispanstream(
    span<charT, Extent> span,
    ios_base::openmode which = ios_base::in);

```

- ¹ *Effects:* Constructs an object of class `basic_ispanstream<charT, traits>`, initializing the base class with `basic_istream(&sb)` and initializing `sb` with `basic_spanbuf<charT, traits>span, which | ios_base::in` (??).

```

basic_ispanstream(basic_ispanstream&& rhs);

```

- ² *Effects:* Move constructs from the rvalue `rhs`. This is accomplished by move constructing the base class, and the contained `basic_spanbuf`. Next `basic_istream<charT, traits>::set_rdbuf(&sb)` is called to install the contained `basic_spanbuf`.

7.4.2 27.x.3.2 Assign and swap [ispanstream.assign]

```
basic_ispanstream& operator=(basic_ispanstream&& rhs);
```

1 *Effects:* Move assigns the base and members of **this* from the base and corresponding members of *rhs*.

2 *Returns:* **this*.

```
void swap(basic_ispanstream& rhs);
```

3 *Effects:* Exchanges the state of **this* and *rhs* by calling `basic_istream<charT, traits>::swap(rhs)` and `sb.swap(rhs.sb)`.

```
template <class charT, class traits, class Allocator>
void swap(basic_ispanstream<charT, traits, Allocator>& x,
         basic_ispanstream<charT, traits, Allocator>& y);
```

4 *Effects:* As if by `x.swap(y)`.

7.4.3 27.x.3.3 Member functions [ispanstream.members]

```
basic_spanbuf<charT>* rdbuf() const noexcept;
```

1 *Returns:* `const_cast<basic_spanbuf<charT>*>(&sb)`.

```
span<charT> span() const noexcept;
```

2 *Returns:* `rdbuf()->span()`.

```
template<ptrdiff_t Extent>
void span(span<charT, Extent> s) noexcept;
```

3 *Effects:* Calls `rdbuf()->span(s)`.

7.5 27.x.4 Class template `basic_ostream` [`ostream`]

```

namespace std {
    template <class charT, class traits = char_traits<charT>>
    class basic_ostream
        : public basic_ostream<charT, traits> {
    public:
        using char_type      = charT;
        using int_type       = typename traits::int_type;
        using pos_type       = typename traits::pos_type;
        using off_type       = typename traits::off_type;
        using traits_type    = traits;

        // 7.5.1, constructors:
        template <ptrdiff_t Extent>
        explicit basic_ostream(
            span<charT, Extent> span,
            ios_base::openmode which = ios_base::out);
        basic_ostream(const basic_ostream& rhs) = delete;
        basic_ostream(basic_ostream&& rhs) noexcept;

        // 7.5.2, assign and swap:
        basic_ostream& operator=(const basic_ostream& rhs) = delete;
        basic_ostream& operator=(basic_ostream&& rhs) noexcept;
        void swap(basic_ostream& rhs) noexcept;

        // 7.5.3, members:
        basic_spanbuf<charT, traits>* rdbuf() const noexcept;

        span<charT> span() const noexcept;
        template<ptrdiff_t Extent>
        void span(span<charT> s) noexcept;
    private:
        basic_spanbuf<charT, traits> sb; // exposition only
    };

    template <class charT, class traits>
        void swap(basic_ostream<charT, traits>& x,
                 basic_ostream<charT, traits>& y) noexcept;
}

```

¹ The class `basic_ostream<charT, traits>` supports writing to objects of class `span<charT, traits>`. It uses a `basic_spanbuf<charT, traits>` object to control the associated span. For the sake of exposition, the maintained data is presented here as:

- `sb`, the `spanbuf` object.

7.5.1 27.x.4.1 `basic_ostream` constructors [`ostream.cons`]

```
template <ptrdiff_t Extent>
explicit basic_ostream(
    span<charT, Extent> span,
    ios_base::openmode which = ios_base::out);
```

- 1 *Effects:* Constructs an object of class `basic_ostream<charT, traits>`, initializing the base class with `basic_ostream(&sb)` and initializing `sb` with `basic_ostreambuf<charT, traits>span, which | ios_base::out` (??).

```
basic_ostream(basic_ostream&& rhs) noexcept;
```

- 2 *Effects:* Move constructs from the rvalue `rhs`. This is accomplished by move constructing the base class, and the contained `basic_ostreambuf`. Next `basic_ostream<charT, traits>::set_rdbuf(&sb)` is called to install the contained `basic_ostreambuf`.

7.5.2 27.x.4.2 Assign and swap [`ostream.assign`]

```
basic_ostream& operator=(basic_ostream&& rhs) noexcept;
```

- 1 *Effects:* Move assigns the base and members of `*this` from the base and corresponding members of `rhs`.
- 2 *Returns:* `*this`.

```
void swap(basic_ostream& rhs) noexcept;
```

- 3 *Effects:* Exchanges the state of `*this` and `rhs` by calling `basic_ostream<charT, traits>::swap(rhs)` and `sb.swap(rhs.sb)`.

```
template <class charT, class traits, class Allocator>
void swap(basic_ostream<charT, traits, Allocator>& x,
         basic_ostream<charT, traits, Allocator>& y) noexcept;
```

- 4 *Effects:* As if by `x.swap(y)`.

7.5.3 27.x.4.3 Member functions [ospanstream.members]

```
basic_spanbuf<charT>* rdbuf() const noexcept;
```

1 *Returns:* `const_cast<basic_spanbuf<charT>*>(&sb)`.

```
span<charT> span() const noexcept;
```

2 *Returns:* `rdbuf()->span()`.

```
template<ptrdiff_t Extent>
void span(span<charT, Extent> s) noexcept;
```

3 *Effects:* Calls `rdbuf()->span(s)`.

7.6 27.x.5 Class template `basic_spanstream` [spanstream]

```
namespace std {
    template <class charT, class traits = char_traits<charT>>
    class basic_spanstream
        : public basic_iostream<charT, traits> {
    public:
        using char_type      = charT;
        using int_type       = typename traits::int_type;
        using pos_type       = typename traits::pos_type;
        using off_type       = typename traits::off_type;
        using traits_type    = traits;

        // 7.6.1, constructors:
        template <ptrdiff_t Extent>
        explicit basic_spanstream(
            span<charT, Extent> span,
            ios_base::openmode which = ios_base::out);
        basic_spanstream(const basic_spanstream& rhs) = delete;
        basic_spanstream(basic_spanstream&& rhs) noexcept;

        // 7.6.2, assign and swap:
        basic_spanstream& operator=(const basic_spanstream& rhs) = delete;
        basic_spanstream& operator=(basic_spanstream&& rhs) noexcept;
        void swap(basic_spanstream& rhs) noexcept;

        // 7.6.3, members:
```

```

    basic_spanbuf<charT, traits>* rdbuf() const noexcept;

    span<charT> span() const noexcept;
        template<ptrdiff_t Extent>
    void span(span<charT> s) noexcept;
private:
    basic_spanbuf<charT, traits> sb; // exposition only
};

template <class charT, class traits>
    void swap(basic_spanstream<charT, traits>& x,
              basic_spanstream<charT, traits>& y) noexcept;
}

```

- 1 The class `basic_spanstream<charT, traits>` supports reading from and writing to objects of class `span<charT, traits>`. It uses a `basic_spanbuf<charT, traits>` object to control the associated span. For the sake of exposition, the maintained data is presented here as:
- `sb`, the spanbuf object.

7.6.1 27.x.5.1 `basic_spanstream` constructors [`spanstream.cons`]

```

template <ptrdiff_t Extent>
explicit basic_spanstream(
    span<charT, Extent> span,
    ios_base::openmode which = ios_base::out | ios_base::in);

```

- 1 *Effects:* Constructs an object of class `basic_spanstream<charT, traits>`, initializing the base class with `basic_istream(&sb)` and initializing `sb` with `basic_spanbuf<charT, traits>span, which` (??).

```

basic_spanstream(basic_spanstream&& rhs) noexcept;

```

- 2 *Effects:* Move constructs from the rvalue `rhs`. This is accomplished by move constructing the base class, and the contained `basic_spanbuf`. Next `basic_istream<charT, traits>::set_rdbuf(&sb)` is called to install the contained `basic_spanbuf`.

7.6.2 27.x.5.2 Assign and swap [`spanstream.assign`]

```

basic_spanstream& operator=(basic_spanstream&& rhs) noexcept;

```

1 *Effects:* Move assigns the base and members of `*this` from the base and corresponding members of `rhs`.

2 *Returns:* `*this`.

```
void swap(basic_spanstream& rhs) noexcept;
```

3 *Effects:* Exchanges the state of `*this` and `rhs` by calling `basic_istream<charT, traits>::swap(rhs)` and `sb.swap(rhs.sb)`.

```
template <class charT, class traits, class Allocator>
void swap(basic_spanstream<charT, traits, Allocator>& x,
         basic_spanstream<charT, traits, Allocator>& y) noexcept;
```

4 *Effects:* As if by `x.swap(y)`.

7.6.3 27.x.5.3 Member functions [`spanstream.members`]

```
basic_spanbuf<charT>* rdbuf() const noexcept;
```

1 *Returns:* `const_cast<basic_spanbuf<charT>*>(&sb)`.

```
span<charT> span() const noexcept;
```

2 *Returns:* `rdbuf()->span()`.

```
template<ptrdiff_t Extent>
void span(span<charT, Extent> s) noexcept;
```

3 *Effects:* Calls `rdbuf()->span(s)`.

8 Appendix: Example Implementations

An example implementation will become available under the author's github account at:
https://github.com/PeterSommerlad/SC22WG21_Papers/tree/master/workspace/Test_basic_spanbuf