Range constructor for `std::span`

Document #:	P1394D1
Date:	2019-06-08
Project:	Programming Language C++
Audience:	LEWG

Reply-to:	Corentin Jabot <corentin.jabot@gmail.com>
	Casey Carter <casey@carter.net>

1 Abstract

This paper proposes that `span` be constructible from any contiguous forwarding-range with a compatible element type. The idea was extracted from P1206.

2 Tony tables

Before	After

`std::vector<int> v(42);`
`std::span<int> foo =`
` v
	view::take(3); //ill-formed`	`std::vector<int> v(42);`
		`std::span foo = v
			view::take(3); //valid`

`std::vector<int> v(42);` `std::span bar(v.begin(), 3); // ill-formed`	`std::vector<int> v(42);` `std::span bar(v.begin(), 3); // valid`

`std::vector<int> get_vector();`
`void foo(std:::span<int>);`
`void bar(std::span<const int>);`
`bar(get_vector()); //valid`
`foo(get_vector()); //ill-formed`
	`std::vector<int> get_vector();`
	`void foo(std::span<int>);`
	`void bar(std::span<const int>);`
	`bar(get_vector()); //valid`
	`foo(get_vector()); //ill-formed`

3 Motivation

`std::span` is specified to be constructible from `Container` types. However, while defined, `Container` is not a concept and as such `ContiguousRange` is more expressive. Furthermore, there exist some non-container ranges that would otherwise be valid ranges to construct span from. As such span as currently specified fits poorly with the iterators / ranges model of the rest of the standard library.

The intent of span was always to be constructible from a wide number of compatible types, whether standard contiguous containers, non-standard equivalent types, or views. This proposal ensure that

span, especially when used as parameter of a function will be constructible from all compatible types while offering stronger and more consistent (in regard to Range) lifetime guarantees.

4 Design considerations

We propose to specify all constructors currently accepting a container or pointers in terms of `ContiguousRange` and `ContiguousIterator` respectively as well as to add or modify the relevant deduction guides for these constructors.

5 Future work

- We suggest that both the wording and the implementation of span would greatly benefit from a trait to detect whether a type has a static extent. Because `std::extent` equals to 0 for types without static extent, and because 0 is a valid extent for containers, `std::extent` proved too limited. However we do not propose a solution in the present paper.

6 Proposed wording

The following wording assumes `std::to_address` will be specialized for `ContiguousIterator` as proposed in [P1474].

Change in **[views.span] 21.7.3**:

```
// [span.cons], constructors, copy, and assignment
constexpr span() noexcept;
template <class It>
constexpr span( pointer ptr It begin, index_type count);
constexpr span(pointer first, pointer last);
template <class It, class End>
constexpr span(It first, End last);

template<size_t N>
constexpr span(element_type (&arr)[N]) noexcept;
template<size_t N>
constexpr span(array<value_type, N>& arr) noexcept;
template<size_t N>
constexpr span(const array<value_type, N>& arr) noexcept;
template<class Container>
constexpr span(Container& cont);
template<class Container>
constexpr span(const Container& cont);
template <class R>
constexpr span(R&& r);
```

```
constexpr span(const span& other) noexcept = default;
template<class OtherElementType, ptrdiff_t OtherExtent>
constexpr span(const span<OtherElementType, OtherExtent>& s) noexcept;

...

}


template<class T, size_t N>
span(T (&)[N]) -> span<T, N>;
template<class T, size_t N>
span(array<T, N>&) -> span<T, N>;
template<class T, size_t N>
span(const array<T, N>&) -> span<const T, N>;
template <class It, class End>
span(It, End) -> span<remove_reference_t<iter_reference_t<It>>>;
template <class It, size_t N>
span(It) -> span<remove_reference_t<iter_reference_t<It>>, N>;

template<class T, size_t N>
span(const array<T, N>&) -> span<const T, N>;
~~template<class Container>~~
~~span(Container&) -> span<typename Container::value_type>;~~
~~template<class Container>~~
~~span(const Container&) -> span<const typename Container::value_type>;~~
template<class R>
span(R&&) -> span<remove_reference_t<iter_reference_t<ranges::iterator_t<R>>>>;
```

In 21.7.3.2 [span.cons]

`constexpr span() noexcept;`

Ensures: `size() == 0 && data() == nullptr`.

Remarks: This constructor shall not participate in overload resolution unless `Extent <= 0` is `true`.

~~`constexpr span(pointer ptr, index_type count);`~~

```
template <class It>
constexpr span(It first, index_type count);
```

Constraints:

- `ConvertibleTo<remove_reference_t<iter_reference_t<It>>(*)[], element_type(*)[]>` is true. [*Note:* The intent is to allow qualification conversions of the iterator reference type to `element_type` — *end note*]

Expects: [~~`ptr`~~ `first`, ~~`ptr`~~ `first + count)` shall be a valid range. If `extent` is not equal to `dynamic_extent`, then `count` shall be equal to `extent`.

Effects: Constructs a `span` that is a view over the range [~~`ptr`~~ `first` , ~~`ptr`~~ `first`

`+ count)`.

Ensures: `size() == count && data() == ptr to_address(first)`.

Throws: Nothing.

```
constexpr span(pointer first, pointer last);
```

Requires: `[first, last)` shall be a valid range. If `extent` is not equal to `dynamic_extent`, then `last - first` shall be equal to `extent`.

Effects: Constructs a span that is a view over the range `[first, last)`.

Ensures: `size() == last - first && data() == first`.

Throws: Nothing.

```
template <class It, class End>
constexpr span(It first, End last);
```

Constraints:

- `ConvertibleTo<remove_reference_t<iter_reference_t<It>>(*)[], element_type(*)[]>` is tru, [*Note:* The intent is to allow qualification conversions of the iterator reference type to `element_type` — *end note*] ,
- `End` models `SizedSentinel<It>`.

Expects:

- If `extent` is not equal to `dynamic_extent`, then `last - first` shall be equal to `extent`.
- `[first, end)` shall be a valid range.

Effects: Constructs a span that is a view over the range `[first, last)`.

Ensures: `size() == last - first && data() == to_address(first)`.

Throws: Nothing.

```
template<size_t N> constexpr span(element_type (&arr)[N]) noexcept;
template<size_t N> constexpr span(array<value_type, N>& arr) noexcept;
template<size_t N> constexpr span(const array<value_type, N>& arr) noexcept;
```

Effects: Constructs a `span` that is a view over the supplied array.

Ensures: `size() == N && data() == data(arr)`.

Remarks: These constructors shall not participate in overload resolution unless:

- `extent == dynamic_extent || N == extent` is `true`, and
- `remove_pointer_t<decltype(data(arr))>(*)[]` is convertible to `element_type(*)[]`.

```
template<class Container> constexpr span(Container& cont);
template<class Container> constexpr span(const Container& cont);
```

Constraints:

- `extent == dynamic_extent` is `true`,
- `Container` is not a specialization of `span`,
- `Container` is not a specialization of `array`,
- `is_array_v<Container>` is `false`,
- `data(cont)` and `size(cont)` are both well-formed, and
- `remove_pointer_t<decltype(data(cont))>(*)[]` is convertible to `ElementType(*)[]`.

Expects: `[data(cont), data(cont) + size(cont))` is a valid range.

Effects: Constructs a `span` that is a view over the range `[data(cont), data(cont) + size(cont))`.

Ensures: `size() == size(cont) && data() == data(cont)`.

Throws: What and when `data(cont)` and `size(cont)` throw.

```
template <class R>
constexpr span(R&& r)
```

Constraints:

- `extent == dynamic_extent` is `true`,
- `R` models `ranges::ContiguousRange` and `ranges::SizedRange`,
- either `R` models *forwarding-range* or `is_const_v<element_type>` is true,
- `R` is not a specialization of `span`,
- `R` is not a specialization of `array`,
- `is_array_v<R>` is `false`,
- `ConvertibleTo<remove_reference_t<iter_reference_t<ranges::iterator_t<R>>>(*)[], element_type(*)[]>` is true [*Note:* The intent is to allow qualification conversions of the iterator reference type to `element_type` — *end note*] .

Effects: Constructs a `span` that is a view over the range `r`.

Ensures: `size() == ranges::size(r) && data() == ranges::data(r)`.

Throws: What and when `ranges::data(r)` and `ranges::size(r)` throw.

```
constexpr span(const span& other) noexcept = default;
```

Ensures: `other.size() == size() && other.data() == data()`.

Add a new section [span.deduction] to describe the following deduction guides:

```
template <class It, class End>
span(It, End) -> span<remove_reference_t<iter_reference_t<It>>>
```

Constraints:

- `It` models `ranges::ContiguousIterator`,
- `End` models `SizedSentinel<It>`.

```
template <class It, size_t N>
span(It) -> span<remove_reference_t<iter_reference_t<It>>, N>
```

Constraints: `It` models `ranges::ContiguousIterator`.

```
template<class R>
span(R&&) -> span<remove_reference_t<iter_reference_t<ranges::iterator_t<R>>>
```

Constraints: `R` models `ranges::ContiguousRange`.

7 References

[P1419] Casey Carter, Corentin Jabot *A SFINAE-friendly trait to determine the extent of statically sized containers*
https://wg21.link/P1419

[P1391] Corentin Jabot *Range constructor for std::string_view*
https://wg21.link/P1391

[P1474] Casey Carter *Helpful pointers for ContiguousIterator*
https://wg21.link/P1474