Road map

- A borrowed string view type
- Adding access control
A borrowed string view type
A borrowed string view type

We can use pointer ranges to represent borrowed strings:

```cpp
struct string_view {
    const char* begin;
    const char* end;
};
```

```cpp
test_case("constructing a string_view") {
    const char s[] = "hello\0world";
    string_view sv1 {s, s + std::strlen(s)};
    CHECK(sv1.end - sv1.begin == 5);
    string_view sv2 {s, s + sizeof s - 1};
    CHECK(sv2.end - sv2.begin == 11);
}
```
A borrowed string view type

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```cpp
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}
```
A borrowed string view type

We can use pointer ranges to represent borrowed strings:

```cpp
struct string_view {
    const char* begin;
    const char* end;
};
```

```cpp
TEST_CASE("constructing_a_string_view") {
    const char s[] = "hello\0world";
    string_view sv1 {s, s + std::strlen(s)};
    CHECK( sv1.end - sv1.begin == 5 );

    string_view sv2 {s, s + sizeof s - 1};
    CHECK( sv2.end - sv2.begin == 11 );
}
```
Adding a member function

In C++, **struct** members are not only variables. Here we add a member function:

```cpp
struct string_view
{
    size_t size() const;  // function member
    const char* begin;    // data member
    const char* end;      // data member
};
```

```cpp
test_case("string_view::size() const")
{
    const char* s = "hello\0world";
    string_view sv {s, s + 11};
    CHECK(sv.size() == 11);
}
```
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    size_t size() const; // function member
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    const char* end;     // data member
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TEST_CASE("string_view::size() const") {
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    string_view sv {s, s + 11};
    CHECK(sv.size() == 11);
}
```
Why a member function?

Why not this?:

```cpp
size_t size(string_view sv) {
    return sv.end - sv.begin;
}
```
Why a member function?

Why not this?:

```cpp
size_t size(string_view sv)
{
    return sv.end - sv.begin;
}
```

Special things members can do:

- access other, private members (we’ll see this soon)
- override lifecycle operations (we’ll see this soon)
- not really nice having global function named size
How do we define a member function?

Member function definitions:

- Have their names prefixed by `Type::`
- Take an implicit parameter `Type* this` or `const Type* this`

```cpp
size_t string_view::size() const
{
    // `this` has type `const string_view*`
    return this->end - this->begin;
}
```
How do we define a member function?

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- Have their names prefixed by `Type::`
- Take an implicit parameter `Type* this` or `const Type* this`

```cpp
size_t string_view::size() const
{
    // `this` has type `const string_view*`
    return end - begin;
}
```

Also, `this->` is implicit on member names!
Aside: Member access syntax

What is the difference between `thing.member` and `thing::member`?

- `Type::member` accesses a member of a type (struct or class)
- `instance.member` accesses a member of a value

Examples:
- `string_view::size` names the `size` member function of the `string_view` type in general
- `an_sv.size` means the `size` member function on a particular instance of `string_view` (`an_sv`)
- `an_sv.begin` means the `begin` member variable of a particular instance of `string_view` (`an_sv`)
- `string_view::begin` (usually) doesn't mean anything
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- `an_sv.begin` means the begin member variable of a particular instance of `string_view` (`an_sv`)
- `string_view::begin` (usually) doesn’t mean anything
Operator overloading

We can tell C++ the meaning of operators (like == and +) for our types.

Declaration (goes in .hxx):

```cpp
bool operator==(string_view, string_view);
```

Definition (goes in .cxx):

```cpp
#include <algorithm>

bool operator==(string_view a, string_view b) {
    return a.size() == b.size() &&
           std::equal(a.begin, a.end, b.begin);
}
```
More operator overloading

We can also make our new type printable.

Declaration (goes in .hxx):

```cpp
std::ostream& operator<<(std::ostream&, string_view);
```

Definition (goes in .cxx):

```cpp
std::ostream& operator<<(std::ostream& os, string_view sv)
{
    return os.write(sv.begin, sv.size());
}
```
Making construction more convenient

A constructor is:

- a member function
- with no result type
- whose name is the same as the name of the struct.

If you declare constructors then all object creation goes via the constructor. For example:
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If you declare constructors then all object creation goes via the constructor. For example:

```cpp
struct string_view
{
    string_view(const char* start, size_t size);
    const char *begin, *end;
};
```

```cpp
const char* s = "hello";
string_view sv {s, s + 5};  // error: no match
string_view sv {s, 5};     // all good
```
Making construction more convenient

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- with no result type
- whose name is the same as the name of the struct.

If you declare constructors then all object creation goes via the constructor. For example:

```c
struct string_view
{
    string_view(const char* start, size_t size);
    const char *begin, *end;
};

const char* s = "hello";
string_view sv {s, s + 5}; // error: no match
string_view sv {s, 5};    // all good
```
How does that make it more convenient though?

Multiple constructors, chosen by argument type:

```cpp
struct string_view
{
    string_view(const char* begin, const char* end);
    string_view(const char* start, size_t size);
    string_view(const char* c_str);
    string_view(String const& s);
    ...
};
```

```cpp
const char* s1 = "hello\0world";
String s2(s1, s1 + 11);
// future constructor
string_view sv1(s1, s1 + 11);
// 1st constructor
string_view sv2(s1, 11);
// 2nd constructor
string_view sv3(s1);
// 3rd constructor
string_view sv4(s2);
// 4th constructor
```
How does that make it more convenient though?

Multiple constructors, chosen by argument type:

```cpp
struct string_view
{
    string_view(const char* begin, const char* end);
    string_view(const char* start, size_t size);
    string_view(const char* c_str);
    string_view(String const& s);
    ...
};
```

```
const char* s1 = "hello\0world";
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Multiple constructors, chosen by argument type:

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struct string_view
{
    string_view(const char* begin, const char* end);
    string_view(const char* start, size_t size);
    string_view(const char* c_str);
    string_view(String const& s);
    ...
};
```

const char* s1 = "hello\0world";
String s2(s1, s1 + 11);       // future constructor
string_view sv1(s1, s1 + 11); // 1st constructor
string_view sv2(s1, 11);      // 2nd constructor
string_view sv3(s1);         // 3rd constructor
string_view sv4(s2);         // 4th constructor
Defining constructors

Constructors have a special syntax for initializing member variables:

```cpp
string_view::string_view(const char* begin0, const char* end0)
    : begin(begin0), end(end0)
{ } // <= regular function body, often left empty
```
Defining constructors

Constructors have a special syntax for initializing member variables:

```cpp
string_view::string_view(const char* begin0,
                         const char* end0)
    : begin(begin0)
      , end(end0)
{ } // <= regular function body, often left empty
```

Constructors can also delegate to other constructors:

```cpp
string_view::string_view(const char* start,
                         size_t size)
    : string_view(start, start + size) { }
```

```cpp
string_view::string_view(const char* c_str)
    : string_view(c_str, std::strlen(c_str)) { }
```
Constructors can enforce invariants

Suppose we decide that a valid string_view should never have a negative size.

C++ can help us guarantee this for all string_views.
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Constructors can enforce invariants

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C++ can help us guarantee this for all string_views.

The first step is to avoid constructing invalid string_views. We could fix improper ranges:

```cpp
string_view::string_view(const char* begin0, const char* end0)
    : begin(begin0),
      end(std::max(begin0, end0))
{ }
```
Constructors can enforce invariants

Suppose we decide that a valid string_view should never has a negative size.

C++ can help us guarantee this for all string_views. The first step is to avoid constructing invalid string_views. Or we could reject improper ranges:

```cpp
string_view::string_view(const char* begin0, const char* end0)
    : begin(begin0)
    , end(end0)
{
    if (end0 < begin0)
        throw std::invalid_argument(BAD_RANGE);
}
```

This ensures we never construct an invalid string_view.
Okay, but what if I…?
Okay, but what if I…?

```cpp
const char* s = "hello";
string_view sv(s);
```
Okay, but what if I...?

```cpp
const char* s = "hello";
string_view sv(s);
sv.end = sv.begin - 3;
```
Okay, but what if I…?

```
const char* s = "hello";
string_view sv(s);
sv.end = sv.begin - 3;

Oh no!
```
Member access control
New idea: Access modifiers

With access modifiers, we can control exactly what client code is allowed to do with our struct:

```cpp
struct Name
{
    // visible to all

    private:
        // visible only to other members

    public:
        // visible to all

};
```
Introducing classes

Technically, **classes** and **structs** differ only in their default access modifier:

- \texttt{class T \{ ... \};} \equiv \texttt{struct T \{ private: ... \};}
- \texttt{struct T \{ ... \};} \equiv \texttt{class T \{ public: ... \};}
Introducing classes

Technically, classes and structs differ only in their default access modifier:

- \texttt{class T \{ ... \}}; \equiv \texttt{struct T \{ private: ... \}};
- \texttt{struct T \{ ... \}}; \equiv \texttt{class T \{ public: ... \}};

But in connotation, we will use class for “smart data” and struct for “plain old data.”
Plan for encapsulation

1. Make member variables \textit{private}
2. Add public member functions to let clients access what we want them to access
3. Don’t add public member functions that let clients do bad things
A string_view class

class string_view
{
public:
    // Constructors:
    string_view(const char*, const char*);
    string_view(String const&);
    ...

    // Accessors:
    const char* begin() const;
    const char* end() const;

private:
    const char* begin_, *end_;
};
Implementing the accessors

const char* string_view::begin() const
{
    return begin_;}

const char* string_view::end() const
{
    return end_;}
Non-member functions must use accessors

Doesn’t work because `string_view::begin_` and `string_view::end_` are private:

```cpp
bool operator==(string_view a, string_view b) {
    return a.size() == b.size() &&
            std::equal(a.begin_, a.end_, b.begin_);
}
```
Non-member functions must use accessors

Works because `string_view::begin()` and `string_view::end()` are public:

```cpp
bool operator==(string_view a, string_view b)
{
    return a.size() == b.size() &&
           std::equal(a.begin(), a.end(), b.begin());
}
```
Non-member functions must use accessors

Works because `string_view::begin()` and `string_view::end()` are public:

```cpp
bool operator==(string_view a, string_view b) {
    return a.size() == b.size() &&
           std::equal(a.begin(), a.end(), b.begin());
}
```

This is a *good thing*, because it means that non-members can't break our carefully preserved invariants.
Welcome to encapsulation!

Encapsulation is a software engineering principle that says:

1. Bundle your data and your operations together
2. Don’t let non-bundled operations mess with your bundled data

Benefits:

• Correctness: only your operations are responsible for preserving invariants, because clients cannot mess them up
• Flexibility: you can change details of the implementation without changing clients, provided the API remains the same
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- Flexibility: you can change details of the implementation without changing clients, provided the API remains the same
Example of flexibility

Client code can’t distinguish this from the previous version:

```cpp
class string_view
{
public:
    string_view(const char*, const char*);
    string_view(const char*, size_t);
    ...

    size_t size() const;
    const char* begin() const;
    const char* end() const;

private:
    const char* start_;  // The character to start from
    size_t size_;       // The size of the string
};
```
– Next: RAII! —
— Next: RAIII!!!! —