

# C++ Club Meeting Notes

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Gleb Dolgich

2020-01-16

# Modules are Coming – Bryce Adelstein Lelbach

- YouTube
- Reddit

*Modules will have a greater impact than any other feature added post-c++98.*

# Modules are Coming – Bryce Adelstein Lelbach

## Textual Inclusion

```
math.hpp  
#pragma once  
  
int square(int a);
```

```
math.cpp  
#include "math.hpp"  
  
int square(int a) { return a * a; }
```

```
main.cpp  
#include "math.hpp"  
  
int main() { return square(42); }
```

## Modular Import

```
math.ixx  
export module math;  
  
export int square(int a);
```

```
math.mxx  
module math;  
  
int square(int a) { return a * a; }
```

```
main.cpp  
import math;  
  
int main() { return square(42); }
```

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## Modules are Coming – Bryce Adelstein Lelbach

*“III-formed, no diagnostics required” (IFNDR)*

# Modules are Coming – Bryce Adelstein Lelbach

```
tree_node.hpp
#pragma once

template <typename T>
struct tree_node {
    T value;
    std::vector<tree_node*> children;
#ifdef DEBUG
    tree_node* parent;
#endif
};
```

a.cpp

```
#define DEBUG
#include "tree_node.hpp"

// ...
```

b.cpp

```
#include "tree_node.hpp"

// ...
```

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# Modules are Coming – Bryce Adelstein Lelbach

## Textual inclusion

```
1 #include <foo.hpp>
2 #include "foo.hpp"
```

## Modular import

```
1 import foo;
2 import <foo.hpp>;
3 import "foo.hpp";
```

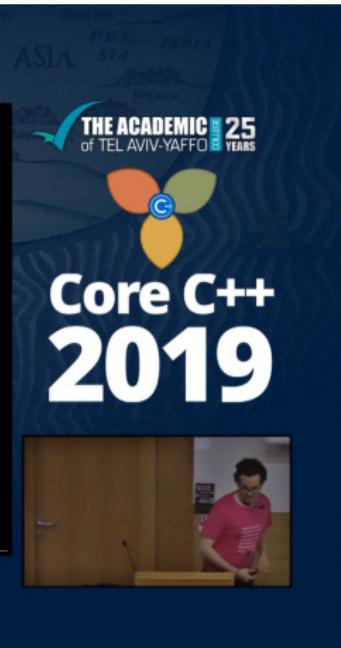
# Modules are Coming – Bryce Adelstein Lelbach

Importable headers:

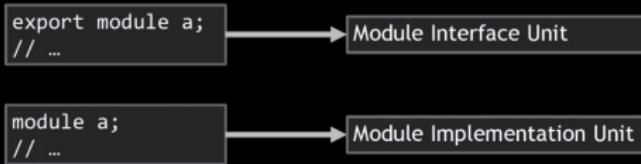
- Most C++ standard library headers\*.
- Some system headers.
- Headers you proclaim importable†.

\* C standard library headers (<cfoo>, <foo.h>) are not required to be importable.

† The mechanism for indicating which headers are importable is implementation defined.

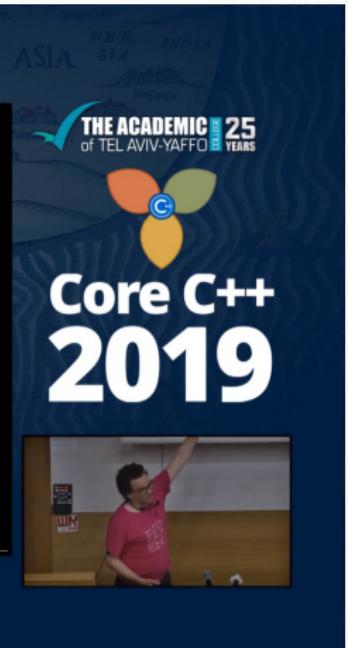


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Only one module declaration per translation unit:

## Interface

```
1 export module a;  
2 //...  
3 export module b; // Error
```

## Implementation

```
1 module a;  
2 //...  
3 module b; // Error
```

# Modules are Coming – Bryce Adelstein Lelbach

## Module unit structure

```
1 export module ...;  
2 import ...;  
3 ...
```

## Modules are Coming – Bryce Adelstein Lelbach

```
1 export declaration ...
2 export {
3     declaration ...
4 }
```

## Modules are Coming – Bryce Adelstein Lelbach

```
1 export {  
2     void f();  
3     struct A;  
4     int i{0};  
5 }
```

```
1 export void f();  
2 export struct A;  
3 export int i{0};
```

## Modules are Coming – Bryce Adelstein Lelbach

```
1 export template <typename T>
2 T square(T t) { return t*t; }
3
4 export template <typename T>
5 struct is_const : false_type {};
6
7 export template <typename T>
8 struct is_const<T const> : true_type {};
```

## Modules are Coming – Bryce Adelstein Lelbach

```
1 export namespace foo { struct A; } // foo::A exported
2
3 namespace foo { struct B; } // foo::B not exported
```

## Modules are Coming – Bryce Adelstein Lelbach

```
1 export typedef int int32_t;  
2  
3 export using unsigned uint32_t;
```

## Modules are Coming – Bryce Adelstein Lelbach

```
1 | export import a;
```

# Modules are Coming – Bryce Adelstein Lelbach

```
a.ixx
export module a;

struct S { int m; };
export S foo();

main.cpp
import a;

int main() {
    auto s0 = foo();
    s0.m = 42;
}
```

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# Modules are Coming – Bryce Adelstein Lelbach

```
a.ixx
export module a;

struct S { int m; };
export S foo();
```

```
main.cpp
import a;

int main() {
    auto s0 = foo();
    s0.m = 42;

    S s1{};
}
```

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# Modules are Coming – Bryce Adelstein Lelbach



a.ixx

```
export module a;  
  
struct S { int m; };  
export S foo();
```

main.cpp

```
import a;  
  
int main() {  
    auto s0 = foo();  
    s0.m = 42;  
  
    decltype(foo()) s1{};  
}
```

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## Modules are Coming – Bryce Adelstein Lelbach

- *Visible*: in scope, can be named
- *Reachable*: in scope, not necessarily namable

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## Kinds of Linkage

	Example	Visible From	Notes
External Linkage	extern void foo(); export void bar(); extern int i{}; export bool b{};	Other translation units.	
Module Linkage	struct S; int foo(); int i{};	This module.	In non-modular units, entities with module linkage have external linkage.
Internal Linkage	static void foo(); static int i{}; bool const b{}; namespace { /* ... */ }	This translation unit.	
No Linkage	int main() { int i{}; }	This scope.	

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# Modules are Coming – Bryce Adelstein Lelbach

```
a.ixx
export module a;
#if defined(DEBUG)
// ...
#else
// ...
#endif

main.cpp
#define DEBUG
import a;
```

The definition of DEBUG isn't seen by the imported module.



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# Modules are Coming – Bryce Adelstein Lelbach

## Module unit structure

```
1 module;  
2 #pp-directive ...;  
3 export module ...;  
4 import ...;  
5 ...  
6 module : private;  
7 ...
```

# Modules are Coming – Bryce Adelstein Lelbach

## Textual Inclusion

```
a.hpp  
#pragma once  
  
struct pimpl;  
  
a.cpp  
#include "a.hpp"  
  
struct pimpl { /* ... */ };
```

## Modular Import

```
a.ixx  
export module a;  
  
export struct pimpl;  
  
module : private;  
  
struct pimpl { /* ... */ };
```

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```
square.ixx
export module square;

export template <typename T>
T square(T a) { return a * a; }
```

```
add.ixx
export module add;

export template <typename T>
T add(T a, T b) { return a + b; }
```

```
math.ixx
export module math;

export import square;
export import add;
```

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```
square.ixx
export module math:square;

export template <typename T>
T square(T a) { return a * a; }
```

```
add.ixx
export module math:add;

export template <typename T>
T add(T a, T b) { return a + b; }
```

```
math.ixx
export module math;

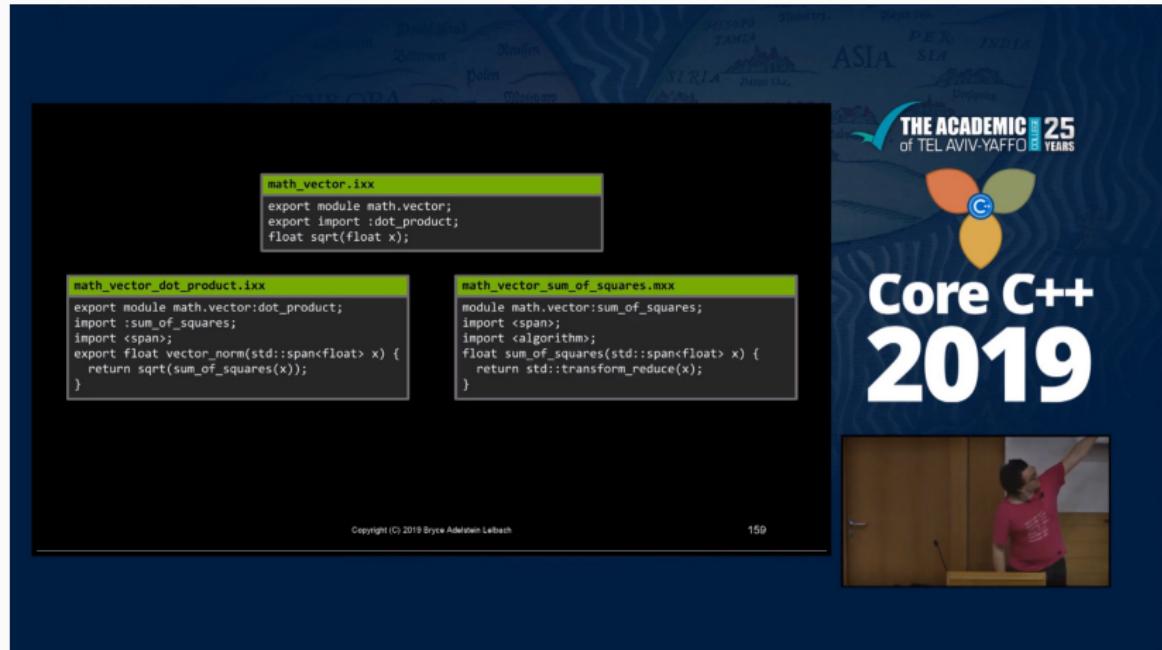
export import :add;
export import :square;
```

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The background of the slide features a detailed map of the Asian continent and parts of the Middle East, with labels for countries like India, China, Japan, and others.

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of TEL AVIV-YAFFO YEARS**

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A small video frame in the bottom right corner shows a man in a red t-shirt standing at a wooden podium, gesturing with his right arm raised.

```
math_vector.ixx
```

```
export module math.vector;
export import :dot_product;
float sqrt(float x);
```

```
math_vector_dot_product.mxx
```

```
export module math.vector:dot_product;
import :sum_of_squares;
import <span>;
export float vector_norm(std::span<float> x) {
    return sqrt(sum_of_squares(x));
}
```

```
math_vector_sum_of_squares.mxx
```

```
module math.vector:sum_of_squares;
import <span>;
import <algorithm>;
float sum_of_squares(std::span<float> x) {
    return std::transform_reduce(x,

```

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## Kinds of Translation Units

	Example	Extension	Artifact	Notes
Non-Modular Unit	#include "..." ...	.cpp	.o	
Header Unit	// Created by: import <...>;	.hpp	.cmi .o (optional)	
Module Interface Unit	export module ...; ...	.ixx	.cmi .o (optional)	Exactly one per module.
Module Implementation Unit	module ...; ...	.mxs	.o	At most one per module.
Module Partition Interface Unit	export module ...:...; ...	.ixx	.cmi .o (optional)	
Module Partition Implementation Unit	module ...:...; ...	.mxs	.o	

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## How are modules found?

- Not specified by the standard.
- Unlike headers, modules are programmatically named.
- A file name <-> module name mapping is not straightforward.
  - Modules have to be precompiled.
  - Partitions span multiple files.

```
bar.ixx
export module foo;
// ...
```

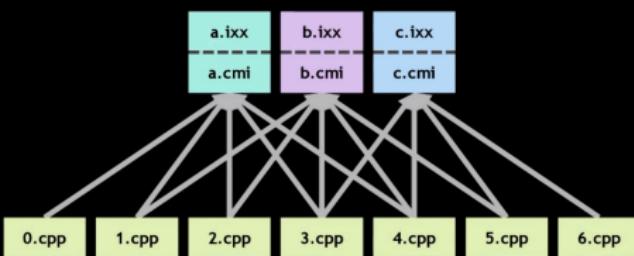


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Implicit Precompilation is Problematic



If precompilation is implicit and builds are parallel,  
how do we decide who builds the CMIs?

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## Modules are Coming – Bryce Adelstein Lelbach

- Tools can no longer rely on simple lookup mechanism (include directories and header file names) to understand C++ projects.
- Dependency scanning now requires a C++ parser, not just a C preprocessor.

## C++ std::string\_view for better performance: An example use case

Article

Reddit

Arthur O'Dwyer: std::string\_view is a borrow type

*Borrow types are essentially “borrowed” references to existing objects. They lack ownership; they are short-lived; they generally can do without an assignment operator. They generally appear only in function parameter lists; because they lack ownership semantics, they generally cannot be stored in data structures or returned safely from functions.*

cppreference: std::basic\_string\_view (C++17)

## A hidden gem: `inner_product`

- Article

# A hidden gem: inner\_product



Conor Hoekstra @code\_report

↳ @cjdb\_ns & @TartanLlama

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This makes me so incredibly happy! I literally just yesterday googled, C++17 / C++20 zip to see if they had anything, because I wrote some code in both C++ and #Python and Python was so much more beautiful.

```
int solve(int h, vector<int> w, vector<int> l) {
    int p = 0;
    for (int i = 0; i < w.size(); ++i)
        p = max(p, w[i] - l[i] / 4);
    return max(0, p - h);
}

def solve(h, w, l):
    p = max(a - b//4 for a, b in zip(w, l))
    return max(0, p - h)
```

29w • 03/12/2018 • 17:47



Conor Hoekstra @code\_report

↳ @cjdb\_ns & @TartanLlama

Also, I just discovered std::inner\_product - a beautiful temporary solution to a lack of zip.

#cpp #inner\_product

```
int solve(int h, vector<int> w, vector<int> l) {
    return max(0, inner_product(begin(w), end(w), begin(l), 0,
        [](){auto a, auto b { return max(a, b); },
        [](){auto a, auto b { return a - b / 4; }}) - h);
}
```

27w • 16/12/2018 • 09:30



## Lingo 0.1.0: Text encoding for modern C++

- GitHub: C++11, MIT
- Reddit

# Argumentum

*Argumentum is a C++17 library for writing command-line program interfaces, inspired by Python argparse*

- GitHub: C++17, MPL
- Reddit



JF Bastien  
@jfbastien

↑ 2 Replies



Today's episode of "something I didn't know about C++":  
you can have a declaration in a for-loop's \*condition\* 😱

```
void use(unique_ptr<int>);  
void drain(vector<unique_ptr<int>> v) {  
    for (int i = 0; auto el = move(v[i]); ++i)  
        use(move(el));  
} // godbolt.org/z/ug2827
```

11/02/2019, 18:21 (10 days ago)  
Twitter Web Client

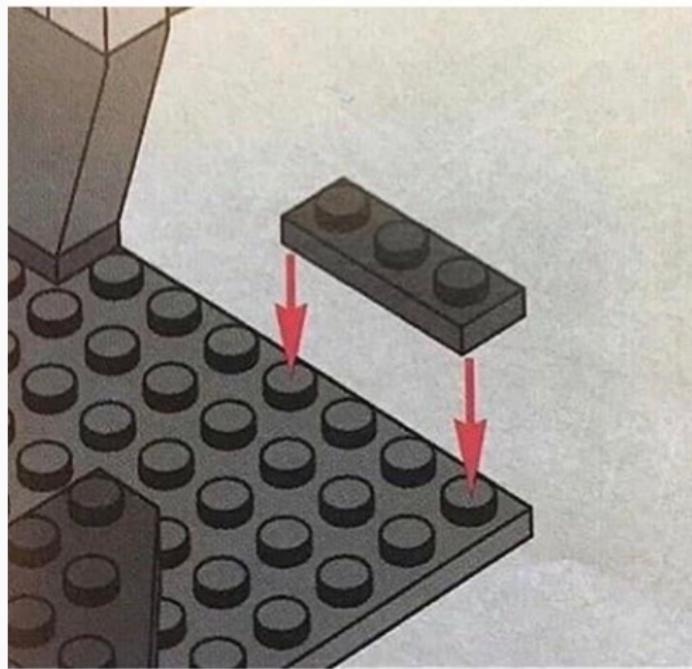
23 Likes

2 Retweets

Thread >

**Senior Developer: Just read the documentation!**

**The documentation:**



## Quote

Ryan Campbell:

*Commenting your code is like cleaning your bathroom – you never want to do it, but it really does create a more pleasant experience for you and your guests.*