Meeting C++

These Aren't the COM Objects You're Looking For

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Abstract

Windows COM is 25 years old. Yet it is relevant today more than ever, because Microsoft has bet its entire modern WinRT API on it (starting with Windows 8/10). But, if you're familiar with the "old" COM with its idioms and SDK helper classes, you're in for a treat. With the advent of modern C++ 17, using COM objects and new Windows APIs in your applications feels like a completely new experience.

In this session, we'll explore how using modern C++ features can radically transform the shape of your COM code. By eliminating a lot of boilerplate, your code will be much more readable and maintainable. Classic COM idioms around activation and QueryInterface() can feel totally different with modern C++ helpers. A beautiful example of modern COM usage is C++/WinRT (now part of Windows SDK). This is a standard C++ language projection for the new Windows Runtime API.

COM memory management, data marshalling, string handling can all feel quite mechanical in nature and very error prone, so a little help from modern C++ facilities would be more than welcomed. Error handling and debugging can be cumbersome for COM like APIs; we'll explore some tricks to improve this experience, as well.

These Aren't the COM Objects You're Looking For

 Part 1 of N

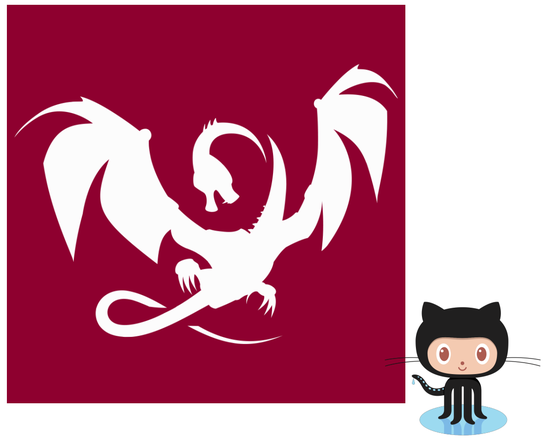
Why COM ?

Why are we talking about this ?

Have we really exhausted all the cool C++ `template<>` topics 😜 ?

Who Am I?

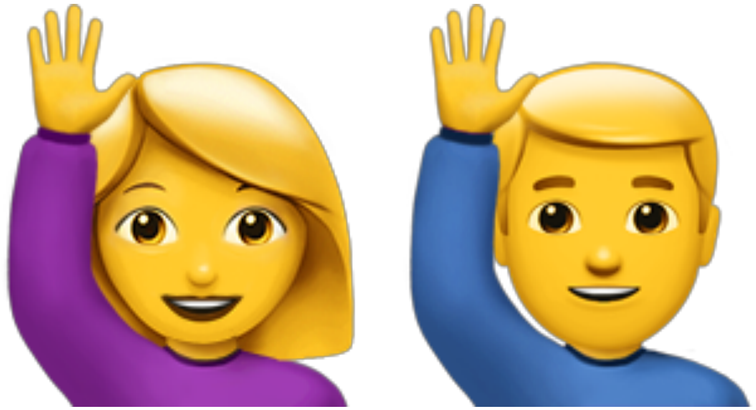
Advanced Installer



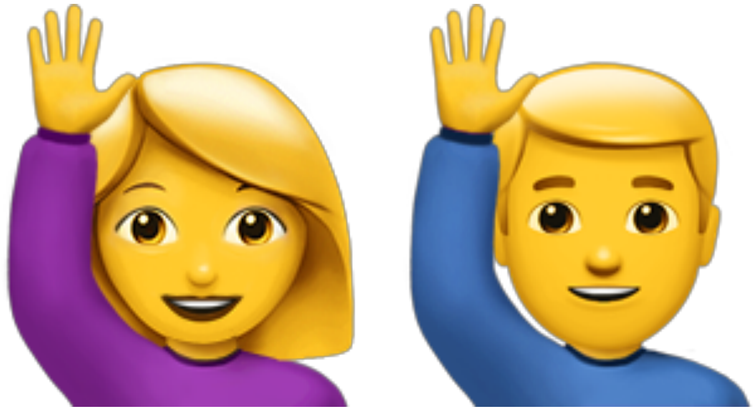
Clang Power Tools

@ciura_victor

How many of you
have done any COM programming
in the last 20 years ?



How many of you
are doing COM programming
currently **(this year) ?**



Let's start using COM...

```
CoInitializeEx()
```

`CoInitializeEx()`

- initializes the COM library for use by the calling **thread**
- sets the thread's concurrency model (`COINIT_APARTMENTTHREADED, COINIT_MULTITHREADED`)
- and creates a new ***apartment*** for the thread (if one is required)

Need to initialize the COM on a *thread* before any COM API calls,

otherwise the function will return `CO_E_NOTINITIALIZED`

`CoInitializeEx()`

`CoInitializeEx()` must be called **once** for each **thread** that uses COM

Multiple calls to `CoInitializeEx()` by the same thread are *allowed*,

but subsequent valid calls return `S_FALSE`

Close COM *gracefully* on a thread: each successful call to `CoInitializeEx()`, must be balanced by a corresponding call to `CoUninitialize()`

“Do. Or do not. There is no try.”

– Yoda

Any Trekkies in the room ?

Any Trekkies in the room ?

I'm sorry...

Some of this material may be unpleasant for you.

So, how can we fix COM init ?

```
CoInitializeEx()
```

RAII

** some details omitted for brevity*

```
class ComInitializerEx
{
public:
  ComInitializerEx(DWORD aComFlags) {
    HRESULT hRes = ::CoInitializeEx(nullptr, aComFlags);
    mClose = (hRes == S_OK);

    if ((hRes != S_OK) && (hRes != S_FALSE))
      ATLASSERT(SUCCEEDED(hRes));
  }

  ~ComInitializerEx() {
    if (mClose)
      ::CoUninitialize();
  }

private:
  bool mClose; // true if COM was initialized by this instance on this thread
};
```

```
void FuncRequiringCom()
{
  ComInitializerEx com(COINIT_MULTITHREADED);
  ...
  // use of COM APIs
}
```

👈 *you can **nest** these objects as needed*

Use it anywhere...

```
class ClassRequiringCom
{
public:
  MethodsRequiringCom();
  ...
private:
  ComInitializerEx com_{ COINIT_MULTITHREADED };
};
```

CoInitializerEx / RAII

- You don't care about the **thread** you're on
- You don't care if you're already **initialized** on this thread
- You can **nest** these objects as needed
- You don't worry about **closing**/unloading COM when you're done

Let's Talk About `Strings`

What is the COM string type ?

BSTR

BSTR

```
typedef WCHAR OLECHAR;
typedef OLECHAR * BSTR;
```

A BSTR is a *composite* data type that consists of:

Length prefix	A four-byte integer that contains the number of bytes in the following data string. It appears immediately before the first character of the data string. This value does not include the terminator.
Data string	A string of Unicode characters. May contain multiple *embedded null* characters.
Terminator	A NULL (0x0000) WCHAR

BSTR

```
typedef WCHAR OLECHAR;
typedef OLECHAR * BSTR;
```

BSTR is a **pointer**

Length prefix	A four-byte integer that contains the number of bytes in the following data string. It appears immediately before the first character of the data string. This value does not include the terminator.
Data string	A string of Unicode characters. May contain multiple *embedded null* characters.
Terminator	A NULL (0x0000) WCHAR

BSTR

```
BSTR str = L"My first COM string";
```

This code:

- **compiles**
- **links**
- **is incorrect (not working)**

If *(by accident)* you pass a *string literal* as an argument to a COM function that is expecting a BSTR, the COM function behaves unexpectedly. 🔥

BSTR

Allocating / Releasing Memory for a BSTR

```
BSTR str = ::SysAllocString(L"My first COM string");

if (str)
{
  UseTheString(str);
  ...

  ::SysFreeString(str);
}
```

“Somebody has to save our skins.”

– Leia Organa

RAII

FTW !

Visual C++ Compiler COM Support

```
#include <comutil.h>
```

Compiler RAII Support Classes:

`_bstr_t`

`_com_ptr_t`

`_variant_t`

`_com_error`
(HRESULT wrapper)

`_bstr_t`

- encapsulates the `BSTR` data type
- manages resource allocation through `SysAllocString` / `SysFreeString` and other APIs
- uses *reference counting* to avoid excessive overhead (**CoW**)
- provides various conversion *constructors:* `const char*`, `const wchar_t*`, `BSTR`, etc.
- provides various *operators:* `=`, `+`, `==`, `!=`, `+=`, `<`, `>`, `char*`, `wchar_t*`, etc.

_bstr_t

```
_bstr_t str(L"My first COM string");

ComApiWithBstrParam(str.GetBSTR());

std::wstring my_std_str = str;
```

Also:

```
_bstr_t other_str(my_std_str.c_str());

if (str == other_str)  // lexicographical compare
{ ... }
```

_com_ptr_t

COM *interface smart pointer*

```
_COM_SMARTPTR_TYPEDEF(IMyInterface, __uuidof(IMyInterface));
```

declares the `_com_ptr_t` specialization: `IMyInterfacePtr`

_com_ptr_t

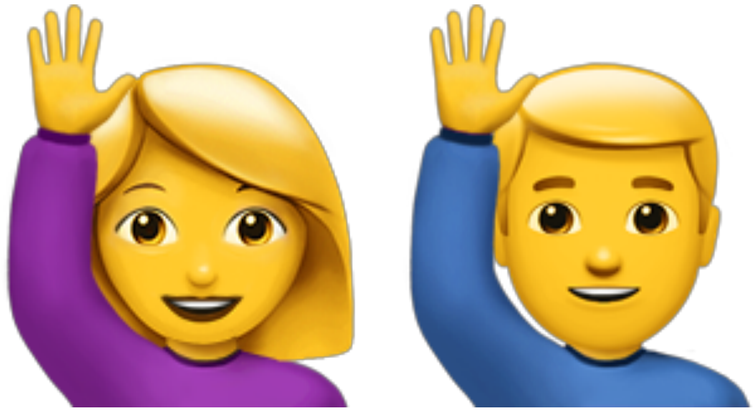
```
_COM_SMARTPTR_TYPEDEF(ITaskbarList3, __uuidof(ITaskbarList3));

ITaskbarList3Ptr taskBar;

HRESULT hr = ::CoCreateInstance(CLSID_TaskbarList, nullptr,
                                CLSCTX_INPROC_SERVER,
                                IID_PPV_ARGS(&taskBar));
ATLASSERT(SUCCEEDED(hr));

if (taskBar)
  taskBar->SetProgressState(wnd, TBPF_INDETERMINATE);
```

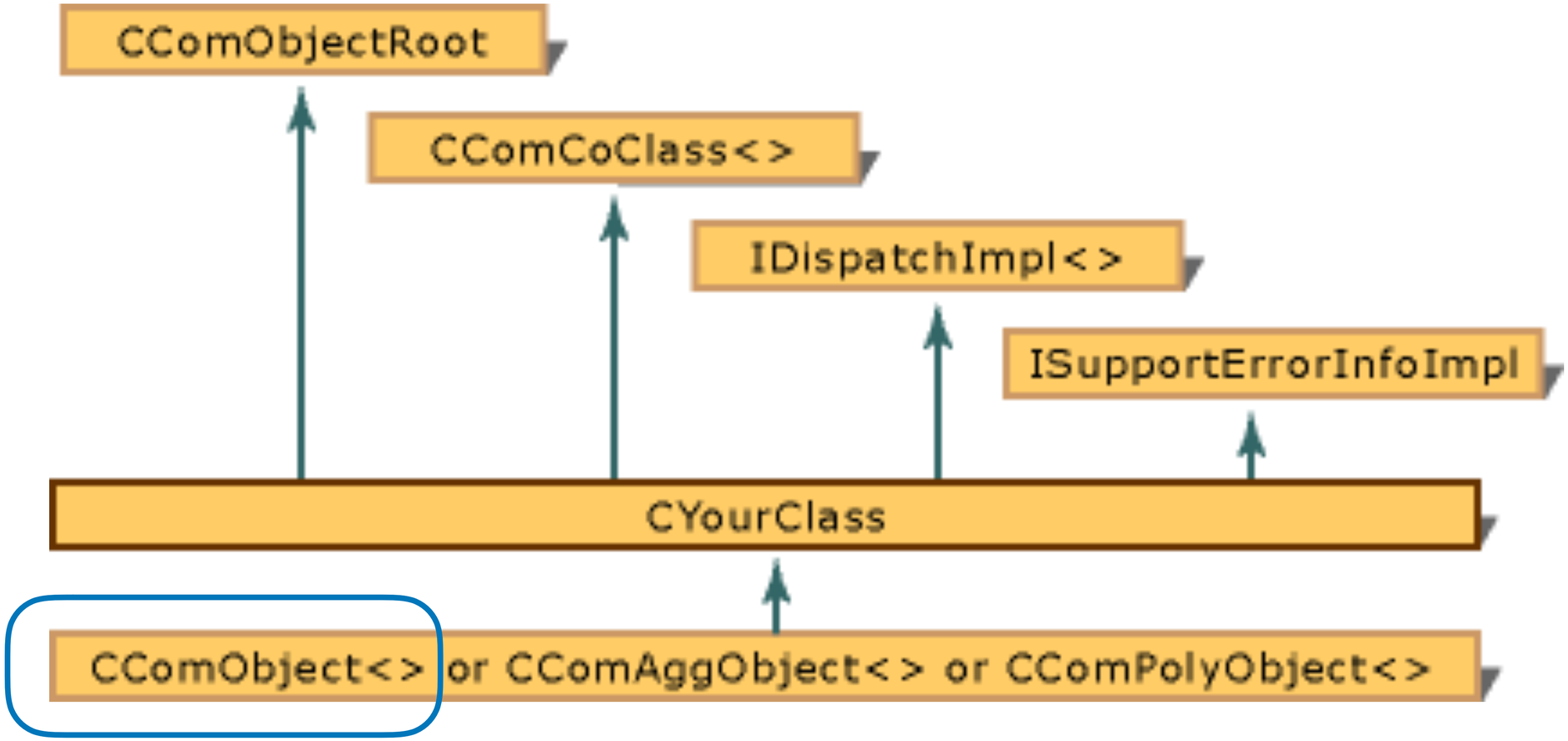
Active Template Library
ATL



ATL

A set of template-based C++ classes

intended to **simplify** COM programming 🤔



CComObject<>

```
template<class Base>
class CComObject : public Base
```

```
CComObject<CMyCircle> * pCircle = nullptr;
HRESULT hRes = CComObject<CMyCircle>::CreateInstance(&pCircle);
ATLASSERT(SUCCEEDED(hRes));

pCircle->AddRef();
pCircle->SetRadius(5.2);
```

CComObject<>

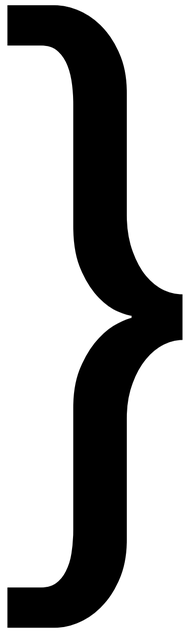
```
class ATL_NO_VTABLE CMyCircle :
    public CComObjectRootEx<CComSingleThreadModel>,
    public CComCoClass<CMyCircle, &CLSID_CMyCircle>,
    public IDispatchImpl<IMyCircle, &IID_IMyCircle, &LIBID_NVC_ATL_COMLib, 1, 0>
{
public:

  DECLARE_REGISTRY_RESOURCEID(IDR_MYCIRCLE)

  DECLARE_NOT_AGGREGATABLE(CMyCircle)

  BEGIN_COM_MAP(CMyCircle)
    COM_INTERFACE_ENTRY(IMyCircle)
    COM_INTERFACE_ENTRY(IDispatch)
  END_COM_MAP()

  DECLARE_PROTECT_FINAL_CONSTRUCT()
  ...
```



BOILERPLATE

CComObject<>

```
class ATL_NO_VTABLE CMyCircle :
    public CComObjectRootEx<CComSingleThreadModel>,
    public CComCoClass<CMyCircle, &CLSID_CMyCircle>,
    public IDispatchImpl<IMyCircle, &IID_IMyCircle, &LIBID_NVC_ATL_COMLib, 1, 0>
{
    ...

    HRESULT FinalConstruct() { return S_OK; }
    void FinalRelease() { }

public:
    CMyCircle() { }
    STDMETHOD(SetRadius)(double val);
    ...
};
```

Actual code we care about

“Your focus determines your reality.”

– Qui-Gon Jinn

CComObject<>

```
template<class Base>
class CComObject : public Base
```

Do you recognize this pattern ?

CRTP

CRTP

```
template<class Base>
class CComObject : public Base
```

- achieves a similar effect to the use of *virtual functions*
- without the costs of dynamic polymorphism (no VTABLE)
- binding done at *compile time*

This pattern is used extensively in the Windows ATL and WTL libraries.

“Power! Unlimited power!”

— Darth Sidious

ATL

<comutil.h>	ATL
_com_ptr_t	CComPtr<T>
_bstr_t	CComBSTR
_variant_t	CComVariant

CComBSTR

- ATL wrapper for the `BSTR` data type
- manages resource allocation through `SysAllocString` / `SysFreeString` and other APIs
- supports ***move*** *semantics* **&&**
- provides various conversion *constructors:* `const char*`, `const wchar_t*`, `BSTR`, etc.
- provides various *operators:* `=`, `+`, `==`, `!=`, `+=`, `<`, `>`, `char*`, `wchar_t*`, `BSTR`, etc.

CComBSTR

```
CComBSTR str(L"My first COM string");

ComApiWithBstrParam(str); // operator BSTR()

std::wstring my_std_str = str;
```

Also:

```
CComBSTR other_str(my_std_str.c_str());

if (str == other_str)  // lexicographical compare
{ ... }
```

“There’s always a bigger fish.”

— Qui-Gon Jinn

ATL CString

```
typedef CStringT<TCHAR, StrTraitATL<TCHAR, ChTraitsCRT<TCHAR>>> CAtlString;
```

- supports both `char` and `wchar_t` through `StringTraits` policy
- manages resource allocation & deallocation
- uses *reference counting* to avoid excessive copy overhead (**CoW**)
- 50+ methods and operators

ATL CString

```
typedef CStringT<TCHAR, StrTraitATL<TCHAR, ChTraitsCRT<TCHAR>>> CAtlString;
```

- provides various conversion *constructors:* `const char*`, `const wchar_t*`, `VARIANT`, etc.
- provides various *operators:* `=`, `+`, `==`, `!=`, `+=`, `<`, `>`, `char*`, `wchar_t*`, etc.
- provides tons of ***utility methods*** and ***string algorithms***

Eg.

`Find`, `FindOneOf`, `Format`, `MakeLower`, `MakeReverse`, `Left`, `Mid`, `Right`, `Replace`, `ReverseFind`, `Tokenize`, `Trim`, etc.

ATL CString

```
CAtlString str(L"My first COM string");

ComApiWithBstrParam(str.AllocSysString()); // allocates an OLE BSTR copy
std::wstring my_std_str = str.GetString(); // get null-term C string
```

Also:

```
CAtlString other_str(my_std_str.c_str());

if (str == other_str)  // lexicographical compare
{ ... }
```

What about this modern COM
I keep hearing about ?

Surely things must have improved in the last 25 years...

Windows Runtime (WinRT)

Windows 8 / 10

“This is a new day, a new beginning.”

– Ahsoka Tano

What is the Windows Runtime ?

Modern class-based, object-oriented Windows API

Metadata about the classes/members

Language projections for natural / familiar use (C++, C#, JavaScript, etc.)

How do I access
the Windows Runtime from C++ ?

Windows Runtime C++ Template Library

WRL

- enables you to more easily **implement** and **consume** COM components
- adds little abstraction over the Windows Runtime ABI (very thin wrapper)
- gives you the ability to control the underlying code (low-level access)
- error handling based on `HRESULT`
- design inspired by **ATL** => can be mixed with existing older COM code
- uses ISO standard C++
- uses smart pointers & RAII
- rather verbose (boilerplate)
- supports UWP apps

Windows Runtime C++ Template Library

C++/CX

- uses **non**-standard C++ language extensions
- terse syntax
- learning curve
- high-level abstraction
- represents `HRESULT` values as **exceptions**
- automates housekeeping tasks
- discontinued...

Let's start using **Windows Runtime**...

WRL

Init...

```
#include <Windows.Foundation.h>
#include <wrl/wrappers/corewrappers.h>
#include <wrl/client.h>

using namespace ABI::Windows::Foundation;
using namespace Microsoft::WRL;
using namespace Microsoft::WRL::Wrappers;
```

WRL

Init...

`Microsoft::WRL::Wrappers::RoInitializeWrapper`

RAII

```
RoInitializeWrapper init(RO_INIT_MULTITHREADED);
if (FAILED(init))
{
  return PrintError(__LINE__, init);
}
```

WRL

Using a class

ABI::Windows::Foundation::IUriRuntimeClassFactory

```
// get the activation factory for IUriRuntimeClass interface
ComPtr<IUriRuntimeClassFactory> uriFactory;
HRESULT hr = GetActivationFactory(
                HStringReference(RuntimeClass_Windows_Foundation_Uri).Get(),
                &uriFactory);
if (FAILED(hr))
{
  return PrintError(__LINE__, hr);
}
```

What is the Windows Runtime string type ?

HSTRING

HSTRING

represents **immutable** string in the Windows Runtime
(handle)

Usage:

`WindowsCreateString()`

`WindowsDuplicateString()`

`WindowsDeleteString()`

`WindowsConcatString()`

https://docs.microsoft.com/en-us/windows/desktop/WinRT/hstring

HSTRING

```
HRESULT WindowsCreateString(
  PCNZWCH sourceString,
  UINT32  length,
  HSTRING *string
);
```

```
HRESULT WindowsDuplicateString(
  HSTRING string,
  HSTRING *newString
);
```

```
HRESULT WindowsDeleteString(
  HSTRING string
);
```

```
HRESULT WindowsConcatString(
  HSTRING string1,
  HSTRING string2,
  HSTRING *newString
);
```

https://docs.microsoft.com/en-us/windows/desktop/WinRT/hstring

HSTRING

`Microsoft::WRL::Wrappers::HString` is the HSTRING wrapper from WRL

```
HString str;
hr = str.Set(L"Hello");
if (FAILED(hr))
{
  return PrintError(__LINE__, hr);
}
```

HSTRING

`Platform::String` is the language projection for C++/CX

Usage:

```
Platform::String ^ s = L"Hello";
```

```
bool String::operator+ (String ^ str1, String ^ str2);
```

```
bool String::operator== (String ^ str1, String ^ str2);
```

“You can’t stop the change, any more than you can stop the suns from setting.”

— Shmi Skywalker

What is C++/WinRT ?

- an ISO standard **C++17** language projection for the **Windows Runtime**
- header-only library
- C++ class wrappers for WinRT APIs
- you can *author* and *consume* Windows Runtime APIs
- supersedes ~~**WRL**~~ and ~~**C++/CX**~~

http://aka.ms/cppwinrt

What is C++/WinRT ?

https://github.com/Microsoft/cppwinrt

Windows SDK 10.0.17134.0
(Windows 10, version 1803)

http://aka.ms/cppwinrt

What is C++/WinRT ?

Project was started a few years back by **Kenny Kerr**.

If you want to learn more about the project & history,

checkout the links below:

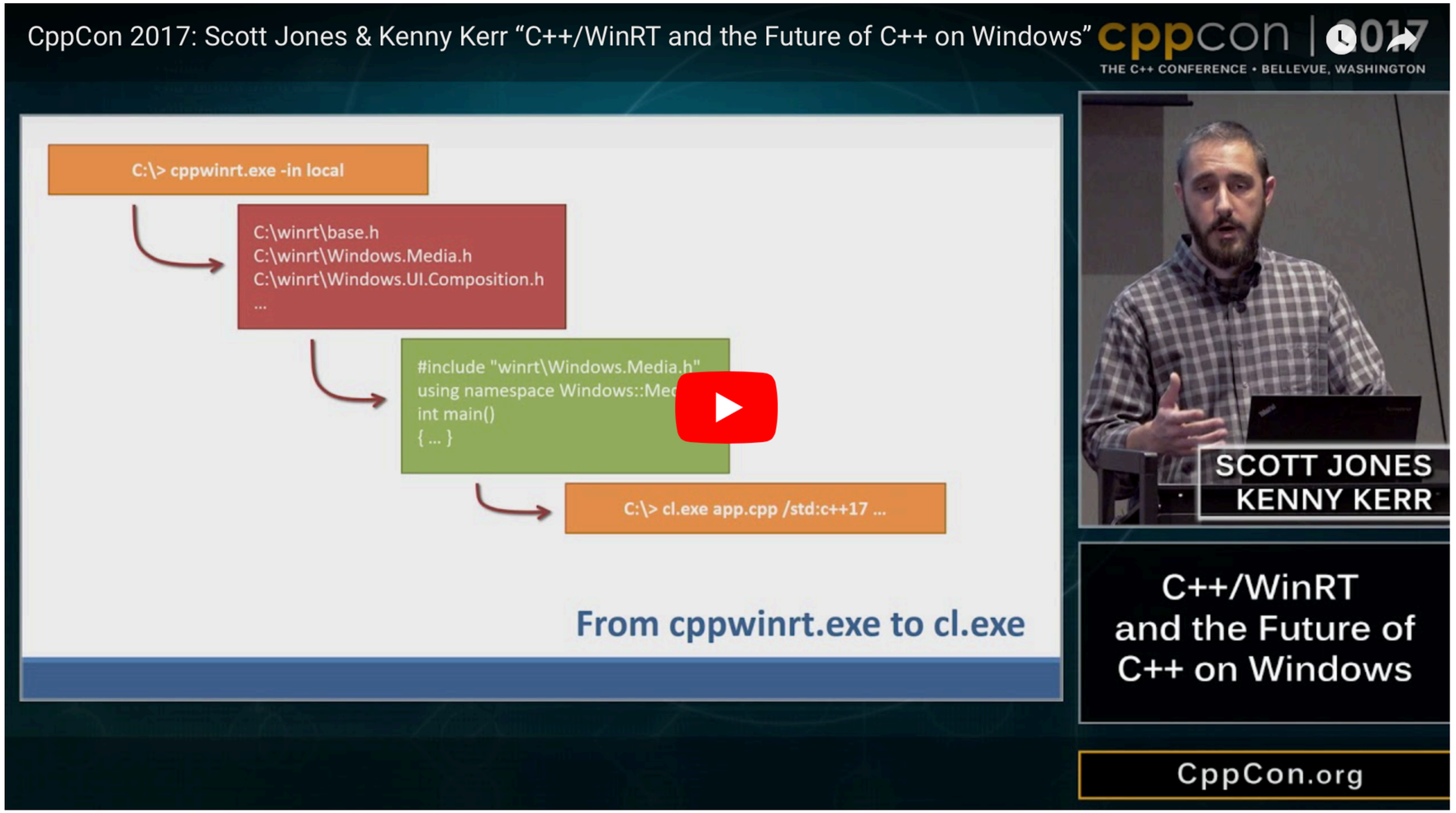
https://moderncpp.com

http://cppcast.com/2015/05/kenny-kerr/

http://cppcast.com/2016/10/kenny-kerr/

https://kennykerr.ca/about/

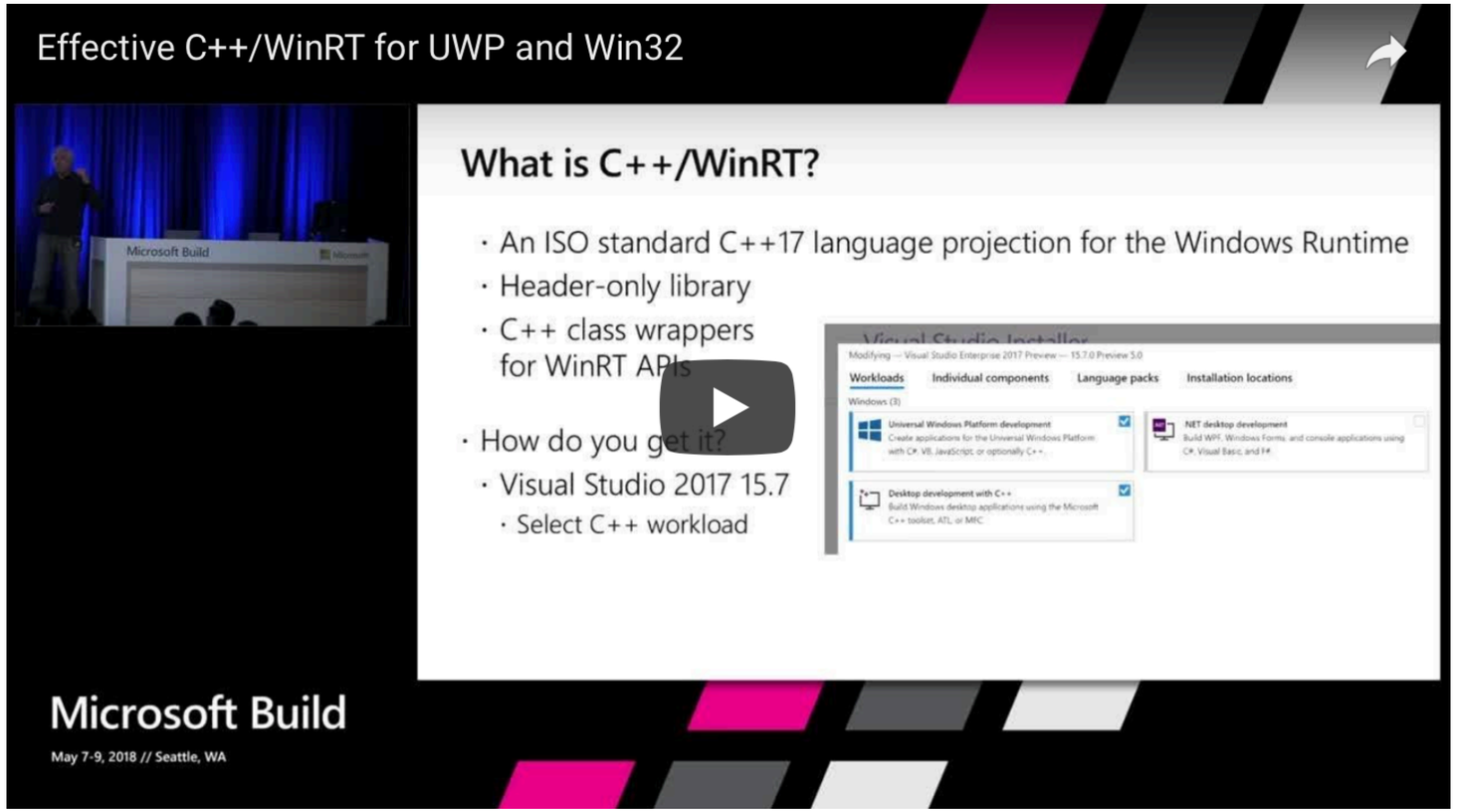
What is C++/WinRT ?



https://www.youtube.com/watch?v=7TdpWB_vRZM

What is C++/WinRT ?

Effective C++/WinRT for UWP and Win32 - *Brent Rector, Kenny Kerr*



Microsoft BUILD 2018

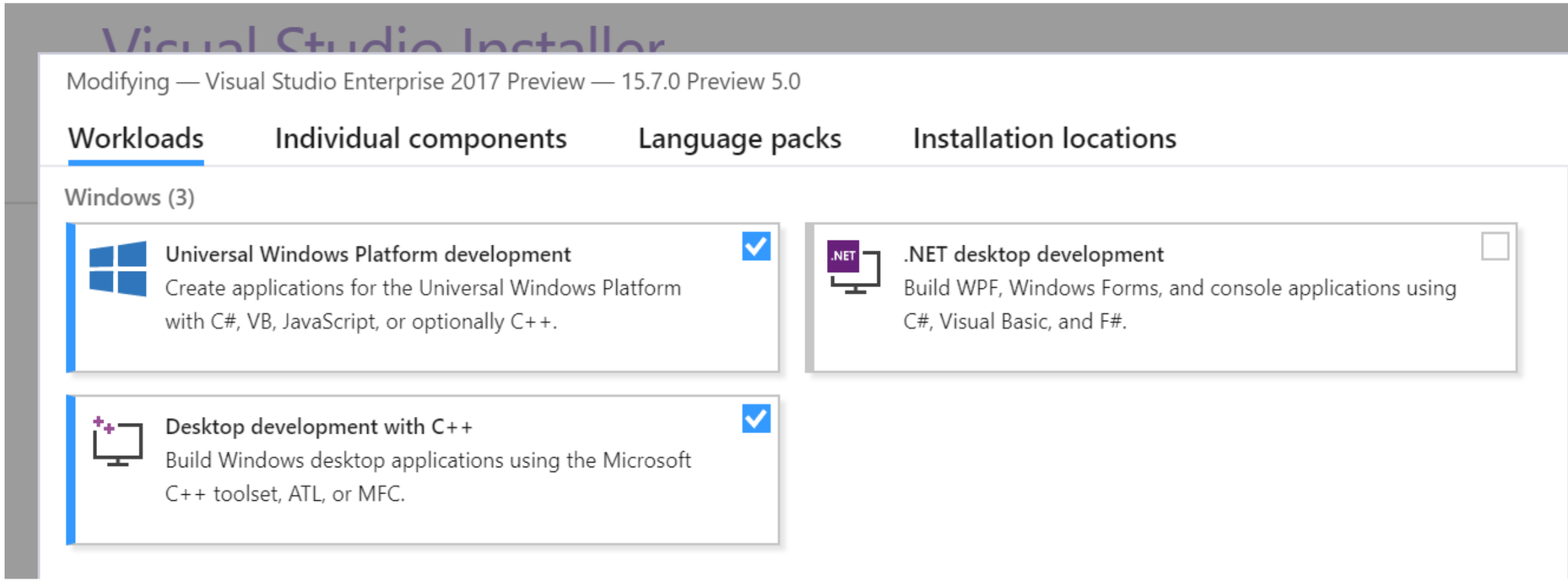
https://channel9.msdn.com/Events/Build/2018/BRK2425

What is C++/WinRT ?

How to get it

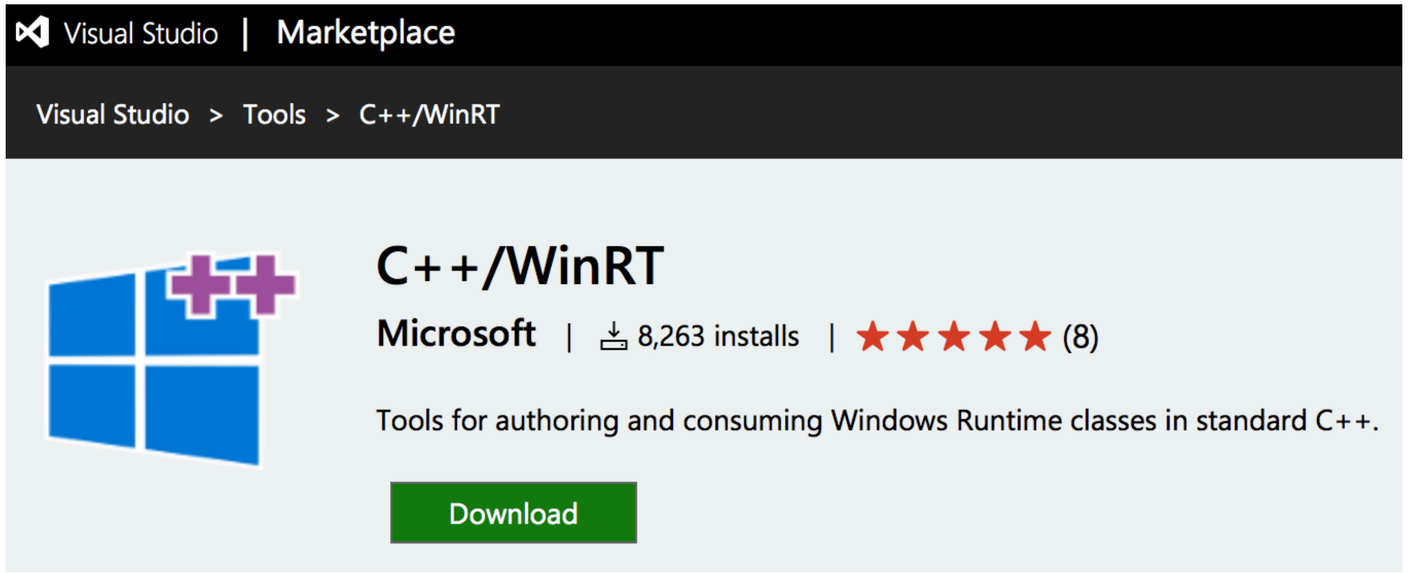
Comes with Visual Studio 2017 (starting with **v15.7**)

✅ Select C++ workload



https://docs.microsoft.com/en-us/windows/uwp/cpp-and-winrt-apis/intro-to-using-cpp-with-winrt

C++/WinRT Visual Studio extension



- Debug visualization of C++/WinRT projected types (similar to C# debugging)
- Project templates for getting started a C++/WinRT application
- MSBuild support for generating C++/WinRT projection headers and component skeletons

https://marketplace.visualstudio.com/items?itemName=CppWinRTTeam.cppwinrt101804264

Let's start using **Windows Runtime**... (again)

C++/WinRT

Init...

```
#pragma comment(lib, "windowsapp")

#include <winrt/base.h>
#include <winrt/Windows.Foundation.h>

using namespace winrt;
using namespace Windows::Foundation;

winrt::init_apartment();
```

```
cl /std:c++17 /EHsc /W4 /WX /I"%WindowsSdkDir%Include\%UCRTVersion%\cppwinrt"
```

C++/WinRT

- performs better and produces smaller binaries than any other language projection
- outperforms handwritten code using the ABI interfaces directly (eg. **WRL**)
- the underlying abstractions use modern C++ idioms, that the Visual C++ compiler is designed to optimize (magic statics, empty base classes, `strlen()` elision)

What is the C++/WinRT string type ?

```
winrt::hstring
```

winrt::hstring

Represents an immutable string consistent with the underlying HSTRING

```
winrt::hstring str(L"Hello!");
```

winrt::hstring

Encapsulates HSTRING behind an interface similar to that of std::wstring

```
hstring() noexcept;
hstring(hstring const & h);
explicit hstring(std::wstring_view const & v);
hstring(wchar_t const * c);
hstring(wchar_t const * c, uint32_t s);
```

```
void Test(hstring const & theHstring,
          wstring_view const & theWstringView,
          wchar_t const * wideLiteral,
          wstring const & wideString)
{
    hstring fromDefault{};

    hstring fromHstring{ theHstring };

    hstring fromWstringView{ theWstringView };

    hstring fromWideLiteral{ wideLiteral };
    hstring fromWideString{ wideString.c_str() };

    hstring fromWideLiteralWithSize{ wideLiteral, 256 };
    hstring fromWideStringWithSize{ wideString.c_str(), 256 };
}
```

winrt::hstring

```
operator std::wstring_view() const noexcept;
```

```
Uri uri{ L"http://example.com" };

// uses hstring's conversion operator to std::wstring_view
std::wstring domain { uri.Domain() };
```

```
hstring Uri::Domain() const;
```

winrt::hstring

An `hstring` is a **range**, so you can use it with range-based `for`, or with `std::for_each`

```
hstring theHstring;
for (const auto & element : theHstring)
{
  std::wcout << element;
}
```

winrt::hstring

hstring is UTF16,
but it plays nice with UTF-8 text

```
winrt::hstring w{ L"Hello!" };

std::string c = winrt::to_string(w);
WINRT_ASSERT(c == "Hello!");

w = winrt::to_hstring(c);
WINRT_ASSERT(w == L"Hello!");
```

ATL CString

BSTR

const wchar_t*

winrt::hstring

CComBSTR

Platform::String

const char*

_bstr_t

XString

wxString

std::string

WTF::String

WTF::CString

folly::fbstring

QString

MFC CString

“I’m just a simple man
trying to make my way in the universe.”
— Jango Fett

So we ended up with something like this...

`XString` ↔  `const char*` ↔ `std::string`

`const char[N]`

+ glue code

String Algorithms

`XString` ⟷  `const char*` ⟷ `std::string`

`const char[N]`

I have a whole talk just on C++17 `std::string_view`

Enough `string_view` to hang ourselves

CppCon 2018

www.youtube.com/watch?v=xwP4YCP_0q0

Is C++17 `string_view`
the answer to all our string problems ?

`std::string_view`

A *lightweight* string-like view into an array of characters.

It can be constructed from a `const char*` (null terminated) or from a *pointer and a length*.

Intended to be used as glue code, to avoid large ***overload sets***.

`std::string_view`

A `string_view` does not manage the **storage** that it refers to.

Lifetime management is up to the user (caller).

Convenience Conversions (and Gotchas)

- `const char *` automatically converts to `std::string` via constructor (*not explicit*)
- `const char *` automatically converts to `std::string_view` via constructor (*not explicit*)
- `std::string` automatically converts to `std::string_view` via *conversion operator*
- can construct a `std::string` from a `std::string_view` via constructor (*explicit*)

`std::string_view`

Design goal: avoid temporary `std::string` objects.

`std::string_view` was designed to interoperate with `std::string` 😈

Caveat: comes with some ***usage complexity*** (gotchas).

“It’s a trap!”

– Admiral Ackbar

On COM...

Windows COM is **25** years old... and it shows this in many corners.

Yet it is **relevant** today more than ever,
because Microsoft has bet its entire modern WinRT API on it.

With the advent of **C++17**,
using COM objects and new WinRT APIs feels like a completely **new experience**.

“The dark side of the COM is a pathway to many abilities some consider to be unnatural.”

— Chancellor Palpatine

One more thing...

xlang

xlang

cross-language

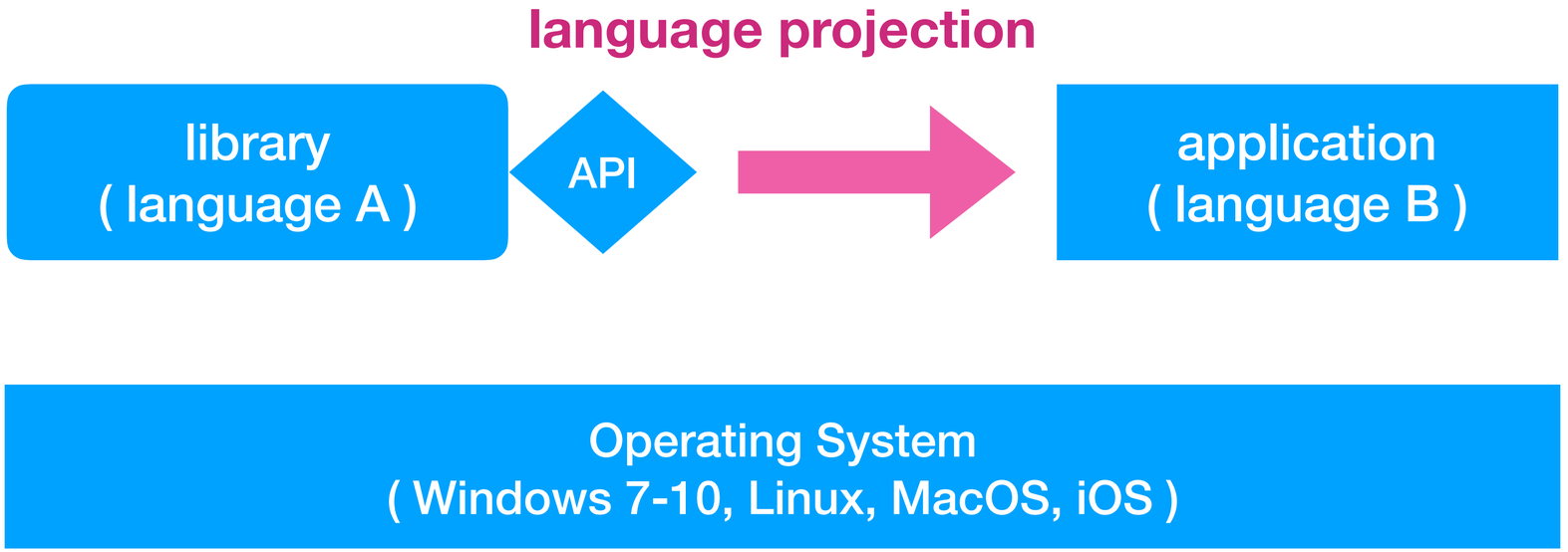
cross-compiler

cross-platform

generalization of **WinRT**

https://kennykerr.ca/2018/10/10/xlang/

xlang


language projection
library
(language A)
API
application
(language B)
Operating System
(Windows 7-10, Linux, MacOS, iOS)

xlang

open-source

WIP

experimental

https://github.com/Microsoft/xlang

xlang

a solid ***metadata reader*** (ISO C++17)

incredibly fast and ***portable*** abstraction
over the ECMA-335 format (WinRT)

Goal: to reach feature parity with C++/WinRT

https://github.com/Microsoft/xlang

What `xlang` project is NOT

`xlang` is not a **port** of the Windows Runtime, COM, DCOM

`xlang` will not port the Windows Runtime APIs

https://github.com/Microsoft/xlang

“Great, kid. Don’t get cocky.”

– Han Solo

C++ Slack is your friend

https://cpplang.slack.com

CppLang Slack auto-invite:
https://cpplang.now.sh/

Cpplang
cpplang.slack.com

CppCast

```
auto CppCast = pod_cast<C++>("http://cppcast.com");
```

Rob Irving **@robwirving**

Jason Turner **@lefticus**

http://cpp.chat

https://www.youtube.com/channel/UCsefcSZGxO9lTBqFbsV3sJg/

https://overcast.fm/itunes1378325120/cpp-chat

Jon Kalb @_JonKalb

Phil Nash @phil_nash

Meeting C++

These Aren't the COM Objects You're Looking For

November, 2018

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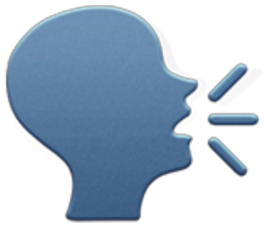
Questions



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