Generating Serialisation Code with Clang

EURO-LLVM CONFERENCE

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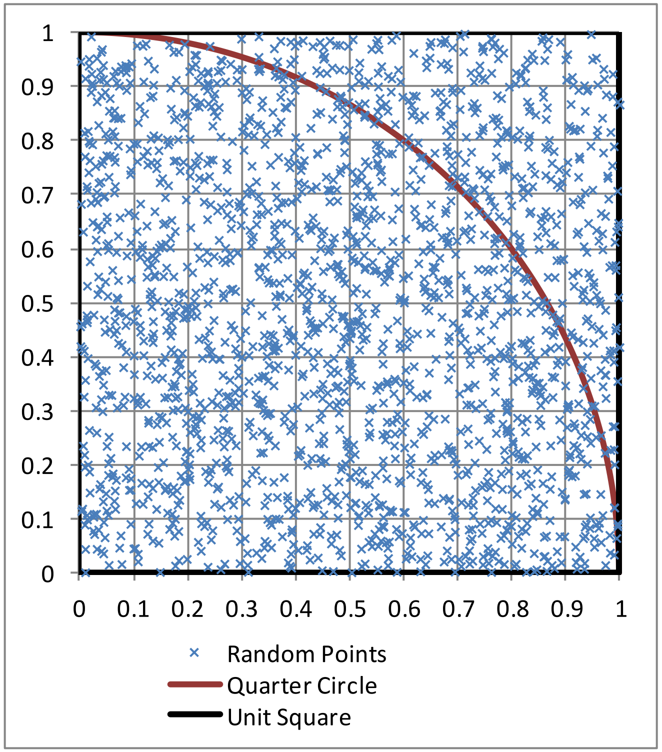
Generating Serialisation Code with Clang
INTRODUCTION TO THE QUANTITATIVE ANALYTICS LIBRARY

- A single C++ library of nearly 10 million lines of code.
- Delivered 2-3 times a week to each of the trading and risk management desks around the bank.
- Calculates risk.
- Calculates how to hedge that risk.

Generating Serialisation Code with Clang
INTRODUCTION TO THE QUANTITATIVE ANALYTICS LIBRARY

- Market behaviour generally too complex to model using closed-form methods.
- Significant amount of calculations in QA use Monte Carlo techniques.
- Monte Carlo computationally expensive.



Generating Serialisation Code with Clang
THE NEED FOR SERIALISATION

- On a single machine, risk calculations would take days or even weeks.
- The requirement is for risk calculations to take anywhere from milliseconds to overnight.
- For speed, calculations are distributed to a grid.
- Currently there are:
  - 55,000 CPU Cores.
  - 25,000 servers and scavenged workstations.
  - 100 million tasks are run each day.
  - 50% CPU core growth each year.
- To communicate between processes on the grid we need to serialise data structures.

Generating Serialisation Code with Clang
THE NEED FOR SERIALISATION

- Hand written serialisation code.
  - Time consuming.
  - Not a scalable solution.
    - Maintenance costs increase as library size increases.
    - Fundamental changes need to be rolled out to every data structure.
  - Prone to human error.
  - Hard to enforce standards.

Generating Serialisation Code with Clang

A BIT OF HISTORY

- Automation of serialisation code generation – previously used Doxygen.
  - Not designed with the intention of generating code for serialisation.
  - Would only run on directories and not individual translation units.
  - Built up massive data structures in memory.
  - Slow.
  - Not a C++ compiler, but a C++ parser.
  - Implementation not separated from functionality.
  - Difficult to integrate with the build system.

Generating Serialisation Code with Clang
ENTER CLANG

- Serialisation with Clang
  - Clang AST easy to use.
  - Fast.
  - Accurate.
  - Can use attributes to identify structures for serialisation.
  - Generate customised errors with respect to serialisation.
  - Runs on translation units.
    - Seamlessly integrated into our Build System.
  - Can easily deliver wholesale changes to serialisation.
    - Easily rollout new output formats, i.e. JSON, XML, Binary.
    - Change existing formats.

Generating Serialisation Code with Clang
THE POWER OF ATTRIBUTES

- Clang has great support for finding attributes.
- Separates functionality from implementation.
  - Can easily add / remove serialisation by adding / removing the attribute.
  - Don’t have to alter the class implementation.
- Hard to mistake the identity of the class.

```
#ifdef __clang__
# define ATTR(...) __attribute__((annotate( " " #__VA_ARGS__ )))
#else
# define ATTR(...)
#endif
```

Generating Serialisation Code with Clang
THE POWER OF ATTRIBUTES

```
#ifndef SIMPLE_H
#define SIMPLE_H

#include "ATTR.h"

class ATTR(serialise) Simple
{
public:
   Simple() : m_SerMember(65) {}

   int m_SerMember;

   virtual void needAMethod();
   virtual ~Simple() {}
};

#endif // SIMPLE_H
```

Generating Serialisation Code with Clang
THE POWER OF ATTRIBUTES

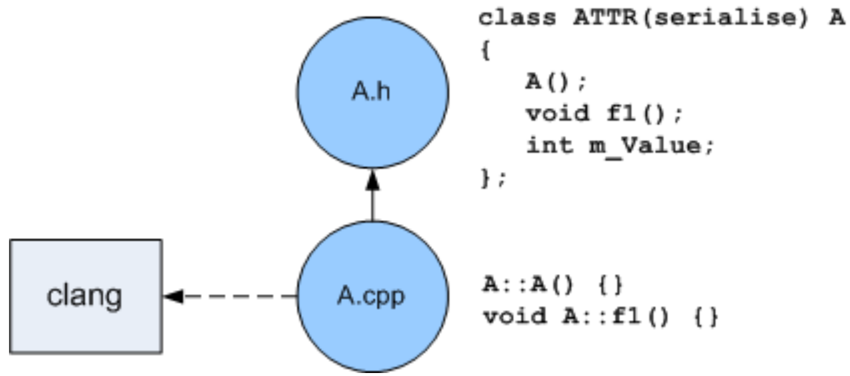
```
#ifndef SIMPLE_H
#define SIMPLE_H

#include "ATTR.h"

class ATTR(serialise) Simple
{
public:
   Simple() : m_SerMember(65), m_NoSerMember(65) {}

   int m_SerMember;
   char ATTR(no_serialise) m_NoSerMember;

   virtual void needAMethod();
   virtual ~Simple() {}
};

#endif // SIMPLE_H
```

Generating Serialisation Code with Clang
THE POWER OF ATTRIBUTES

```
#ifndef SIMPLE_H
#define SIMPLE_H

#include "ATTR.h"

class ATTR(hand_serialise(HandSer.h)) Simple
{
public:
   Simple() : m_SerMember(65) {}

   int m_SerMember;

   virtual void needAMethod();
   virtual ~Simple() {}
};

#endif // SIMPLE_H
```

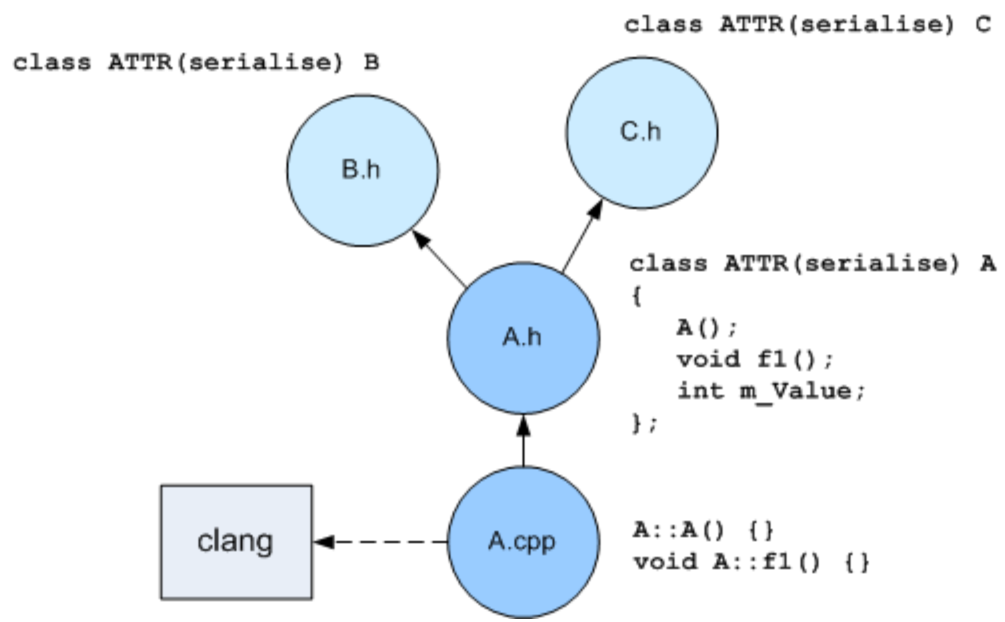
Generating Serialisation Code with Clang
ONCE AND ONLY ONCE

- How do we identify the data structures for which we want to generate serialisation code?
- How do we ensure each data structure has serialisation code generated?
- How do we ensure this is all done seamlessly within the build system?



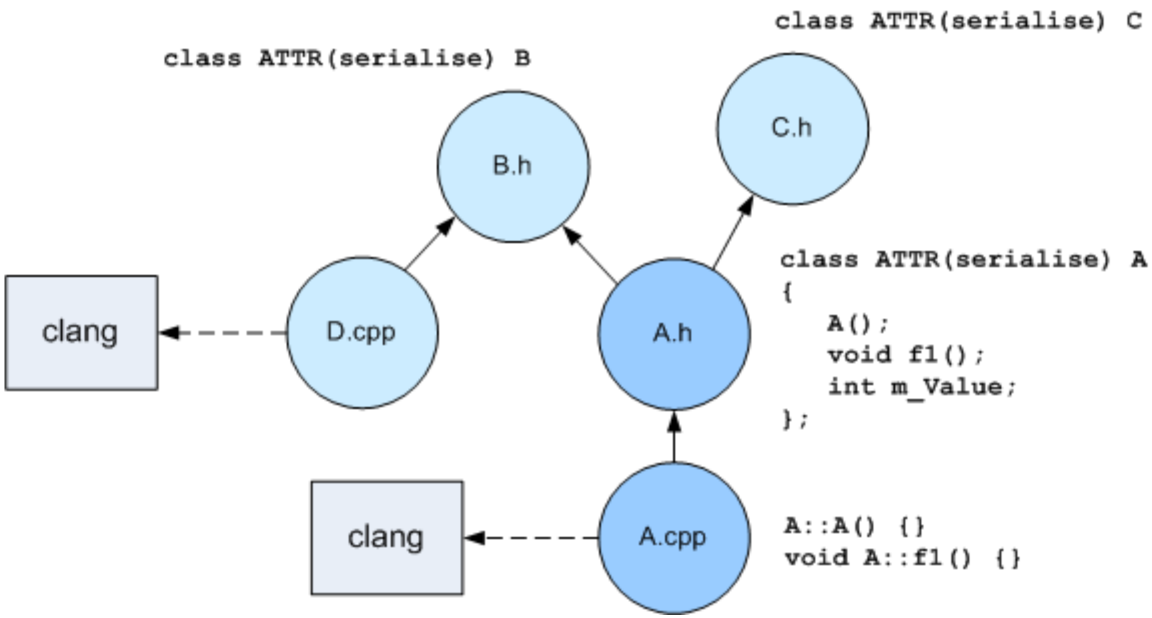
Generating Serialisation Code with Clang
ONCE AND ONLY ONCE

- Translation units can include many declarations of classes that require serialisation.



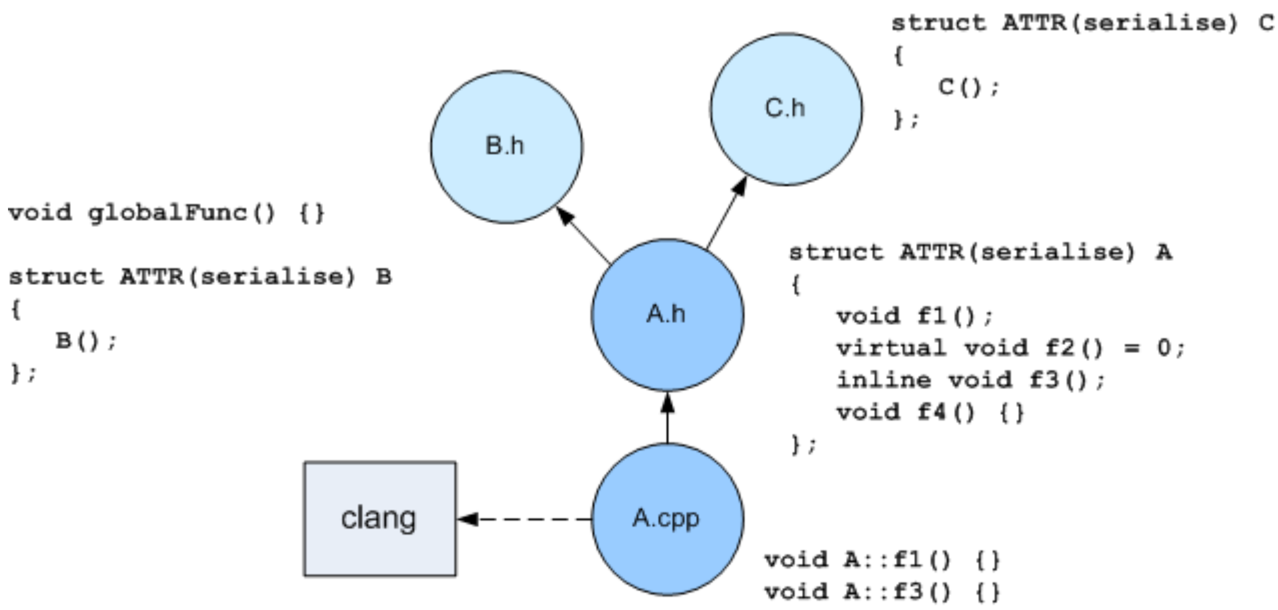
Generating Serialisation Code with Clang
ONCE AND ONLY ONCE

- Class declarations that require serialisation can be included in more than one translation unit.



Generating Serialisation Code with Clang
FINDING THE KEY FUNCTION

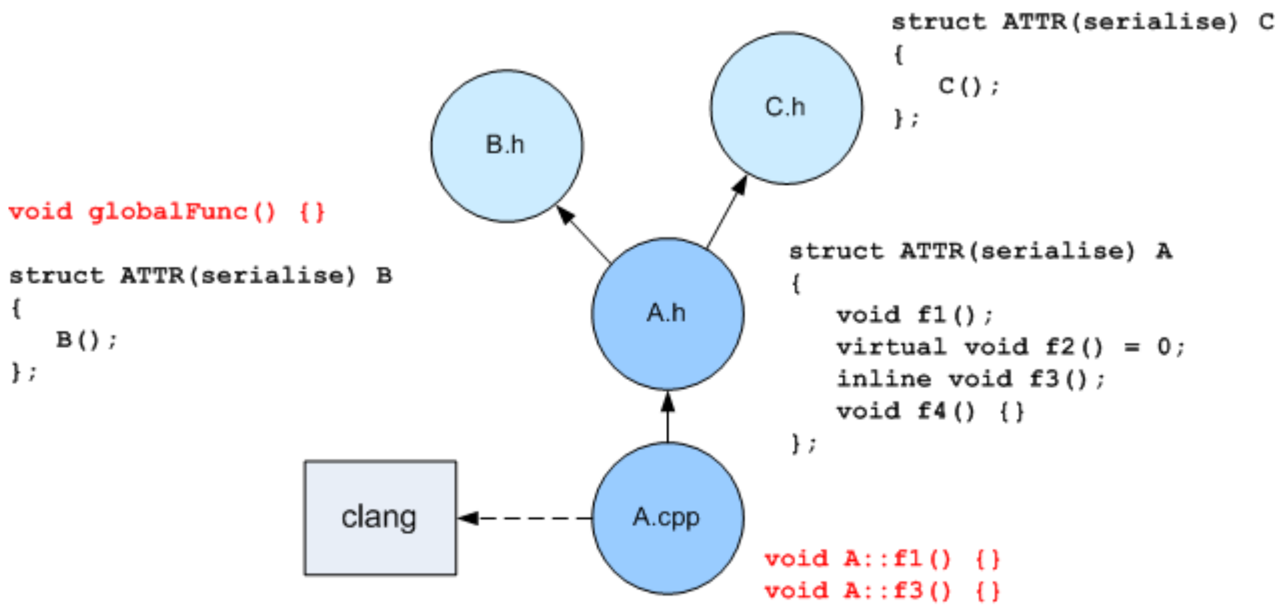
- Must find a "key function".
  - A method that makes this class unique to this translation unit.
  - Same as Clang "key function" for finding where to place a v-table.
  - However, don't care if it is virtual or non-virtual.



Generating Serialisation Code with Clang
FINDING THE KEY FUNCTION

- Visit each method of the Clang AST (CXXMethodDecl).

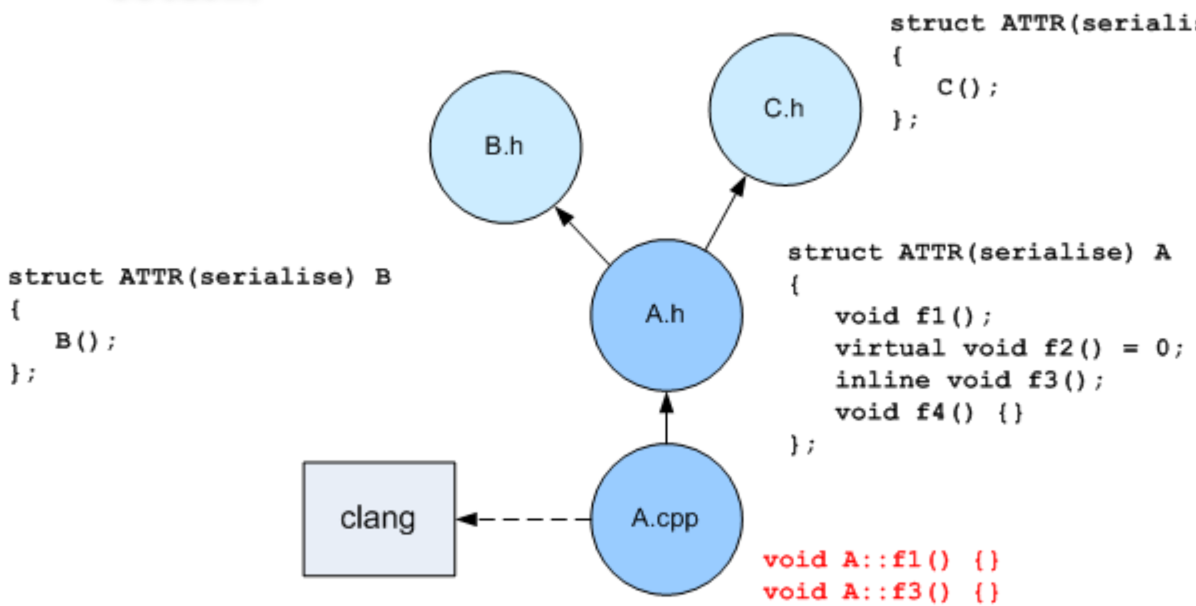
```
void Action::VisitCXXMethodDecl( CXXMethodDeclIter iter )
    { }
```



Generating Serialisation Code with Clang
FINDING THE KEY FUNCTION

- Throw away methods that have no declaration context (global scope).

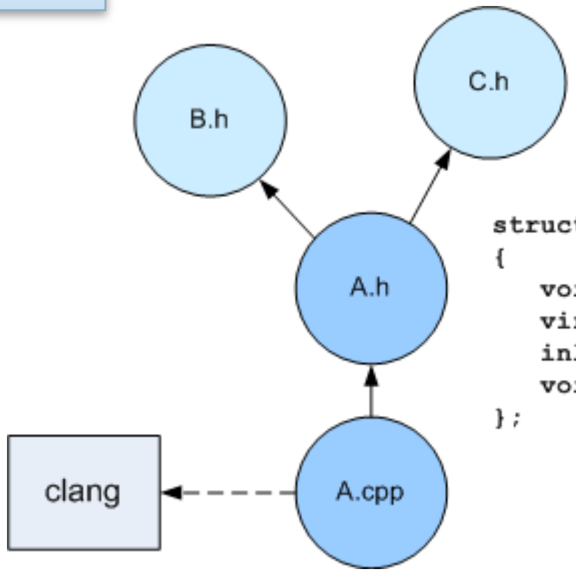
```
clang::DeclContext const * declCtxt(iter->getDeclContext());

   if (!declCtxt)
      return;
```



Generating Serialisation Code with Clang
FINDING THE KEY FUNCTION

- If the declaration context is a class or struct (CXXRecordDecl) then take a closer look at this class.
- Traverse each method of this CXXRecordDecl looking for a key method.

```
if (clang::CXXRecordDecl const * cxxRecDecl =
  dyn_cast<clang::CXXRecordDecl>(declCtxt))
```

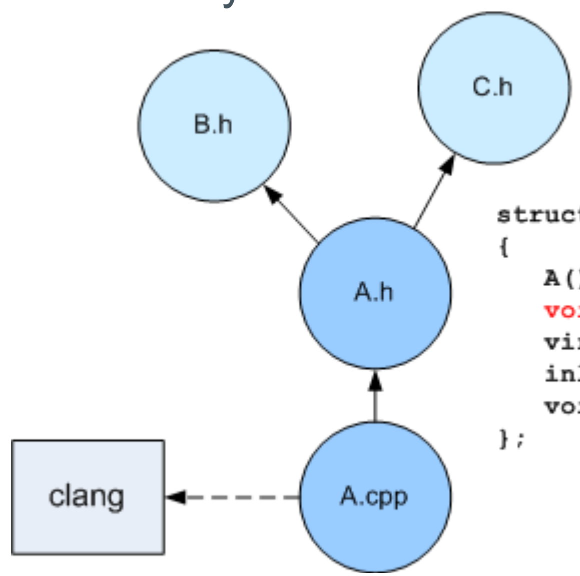



```
struct ATTR(serialise) A
{
    void f1();
    virtual void f2() = 0;
    inline void f3();
    void f4() {}
};
```

Generating Serialisation Code with Clang
FINDING THE KEY FUNCTION

- Key function won't be unique if it is in the header file, i.e.:
  - Implicitly generated by the compiler (i.e. constructors).
  - Inline specified or have an inline body.
- Pure virtual function – most probably has no implementation.
- If the function is none of these things, it is the key function.

```
if (methodDecl->isPure())
   continue;
if (methodDecl->isImplicit())
   continue;
if (methodDecl->isInlineSpecified())
   continue;
if (methodDecl->hasInlineBody())
   continue;
foundDecl = methodDecl;
break;
```




```
struct ATTR(serialise) A
{
    A() {}
    void f1();
    virtual void f2() = 0;
    inline void f3();
    void f4() {}
};
```

Generating Serialisation Code with Clang
CAN'T FIND A KEY FUNCTION

- What if a class that requires serialisation has no key function?
  - Manually add a "key method".
  - *size_t = sizeof(T)* ensures that T is a complete type.

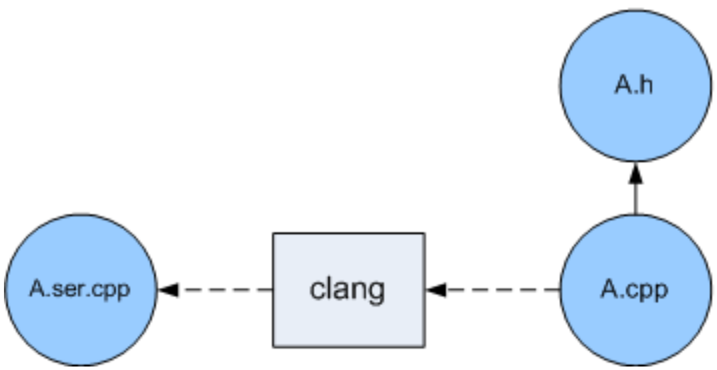
```
struct Reflection
{
  template<typename T> static void owner(const T &, const size_t =
   sizeof(T));
};
```

```
#define OWN_THE_SERIALISATION_FOR(TYPE) \
    template<> void Reflection::owner(const TYPE &, const size_t);
```

```
OWN_THE_SERIALISATION_FOR(A)
```

Generating Serialisation Code with Clang
GENERATING FOR A SIMPLE CLASS

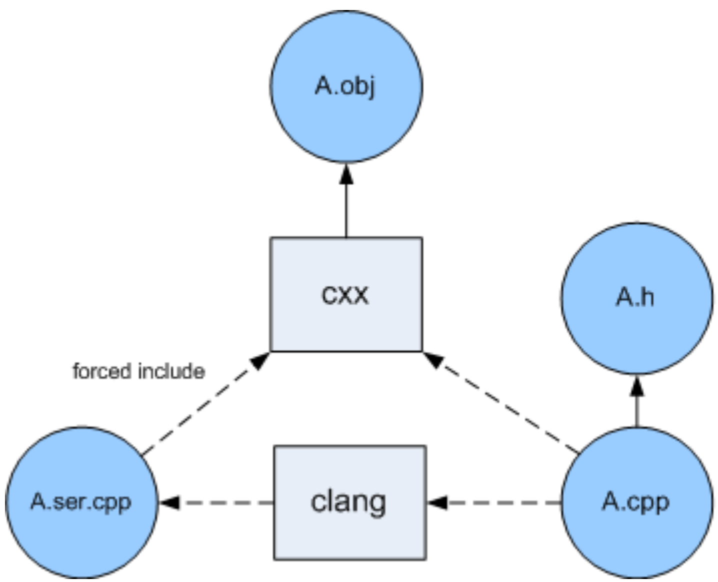
- Now that we have found a unique identifier for struct A (the key method of A), check that it has attribute "serialise".
  - If so, Clang can easily generate code capable of serialising the object in the file A.ser.cpp.




```
struct ATTR(serialise) A
{
    A() {}
    void f1();

    int m_Value;
};


A::A() : m_Value(25) {}
void f1() {}
```

Generating Serialisation Code with Clang
COMPILING FOR A SIMPLE CLASS

- The build system then "force includes" the file A.ser.cpp into A.cpp.
- Seamlessly, the developer's struct A is now capable of being serialised / de-serialised.

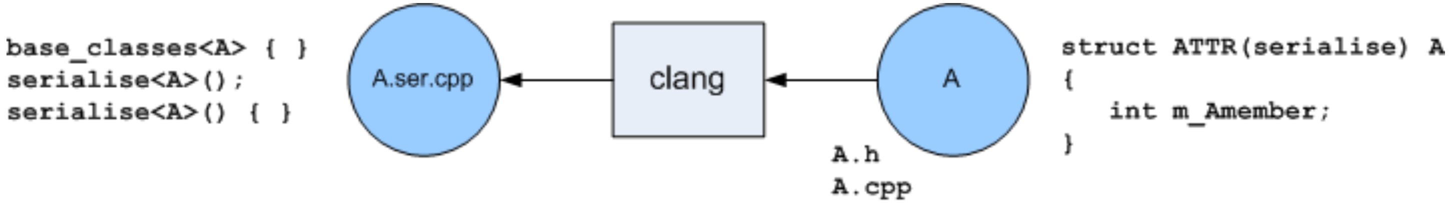



```
struct ATTR(serialise) A
{
   A() {}
   void f1();

   int m_Value;
};


A::A() : m_Value(25) {}
void f1() {}
```

Generating Serialisation Code with Clang

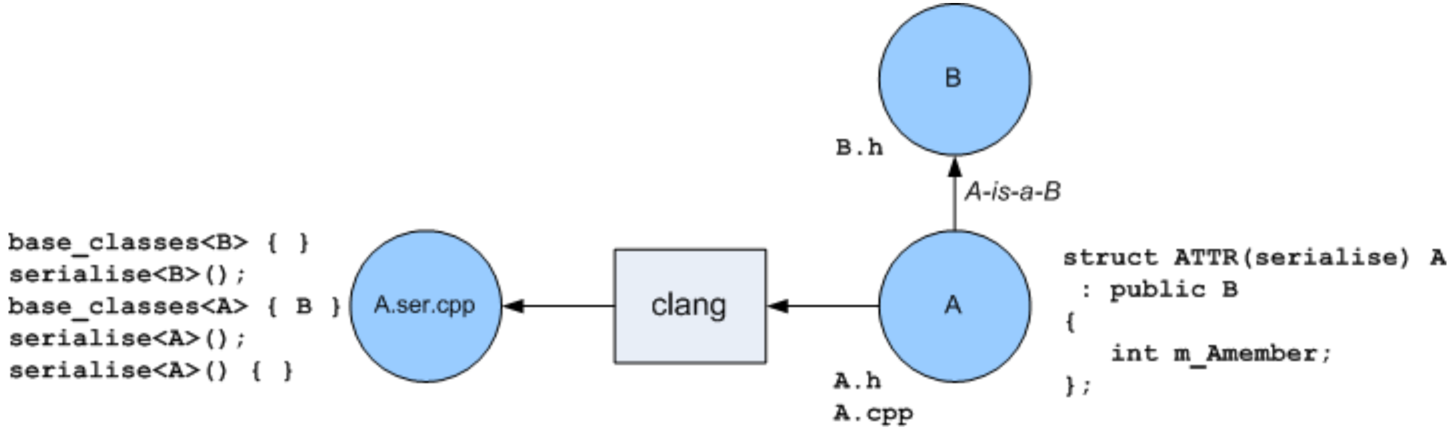
WHAT CLANG GENERATES – ONE CLASS

- Code generation for a simple struct (or class) A.
  - Generate the declaration for the serialise function.
  - Generate the definition for the serialise function.



Generating Serialisation Code with Clang
WHAT CLANG GENERATES – INHERITANCE

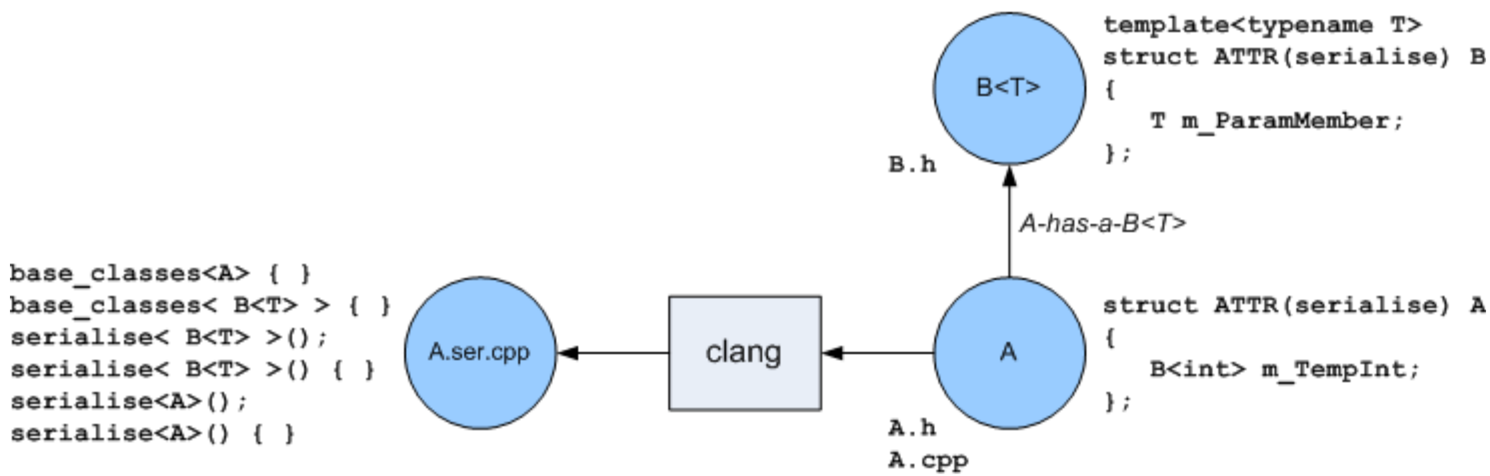
- When struct A derives from B:
  - Since we want our build system to compile this file straight away, the declaration for serialising B (*serialise<B>()*) must be generated now in the file A.ser.cpp.
    - Without this, “gates” in the build system would have to be introduced.
  - All classes that inherit from B will generate this declaration. Clang will generate the definition for *serialise<B>()* when processing B.



Generating Serialisation Code with Clang

WHAT CLANG GENERATES – IMPLICIT TEMPLATES

- For templated types we chose to generate templates rather than specialisations – less code generation required.
- The declaration and definition for templated types must be generated by Clang.



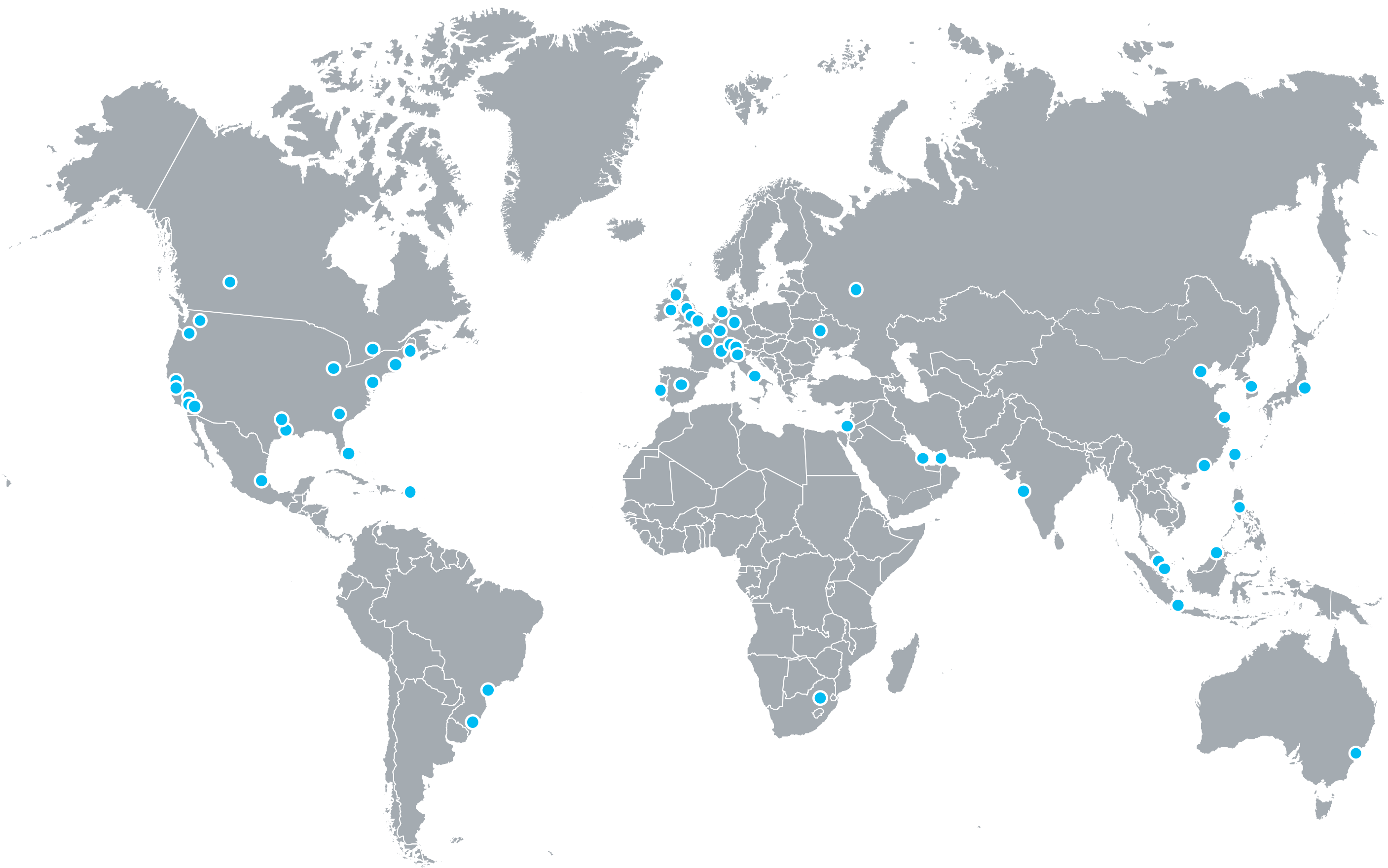
Generating Serialisation Code with Clang
OTHER USES OF CLANG WITHIN BARCLAYS

- Automatic generation of the Quantitative Analytics library interface.
  - Keyhole interface similar to COM.
  - Must maintain backwards compatibility.
  - Generates C++, COM, SWIG (Java), .NET (C++/CLR) interfaces automatically.

- Enforcing standards on the use of framework classes.

- Thread safety mark-up.

QUESTIONS



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