Checking Coding Rules in OO Languages Using CRISP

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COST Action IC0701 Meeting, Madrid December 2008

Motivation: C++ "Strange" Behavior

```
class A
{
public:
  A();
  virtual void func();
};

class B : public A
{
  B() : A() {}
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```

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A::A() {
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B *d = new B();

// A::func or B::func?
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Coding Rule:

"Do not invoke virtual methods of the declared class in a constructor or destructor."

Coding Rules

Definition

Coding Rules constrain admissible constructs of a language to help produce more reliable and maintainable code.

Standard coding rule sets do exist, e.g.:

- High-Integrity C++ (HICPP): general C++ applications
- MISRA-C (C language): automotive industry / embedded systems

Many organisations need to write their own rule sets or adapt existing ones.

Other Tools

Proprietary tools:

- Compilers: IAR Systems (C)
- QA: Parasoft, Klocwork, Coverity, Semmle Code (Java)

Free software:

- Checkstyle (Java)
- Gendarme (ECMA CIL, Mono and .Net)

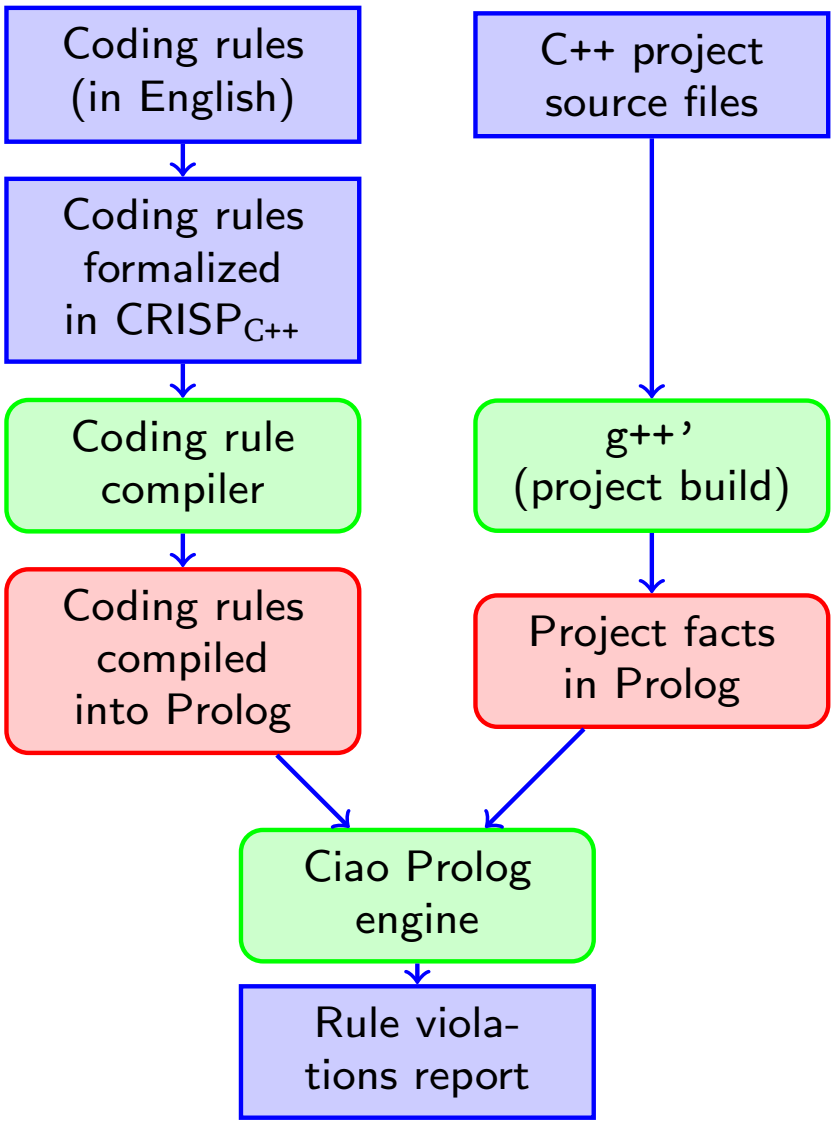
Drawbacks:

- Lack of appropriate extensibility mechanisms
- Ambiguity in natural language
- Interoperability is difficult

Proposed Approach

1. Formalize rules in a logic-based specification language that is executable: CRISP
2. Use GCC for gathering necessary program information

Our Rule Checking Procedure



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3. Search (using a Prolog engine) for a counterexample

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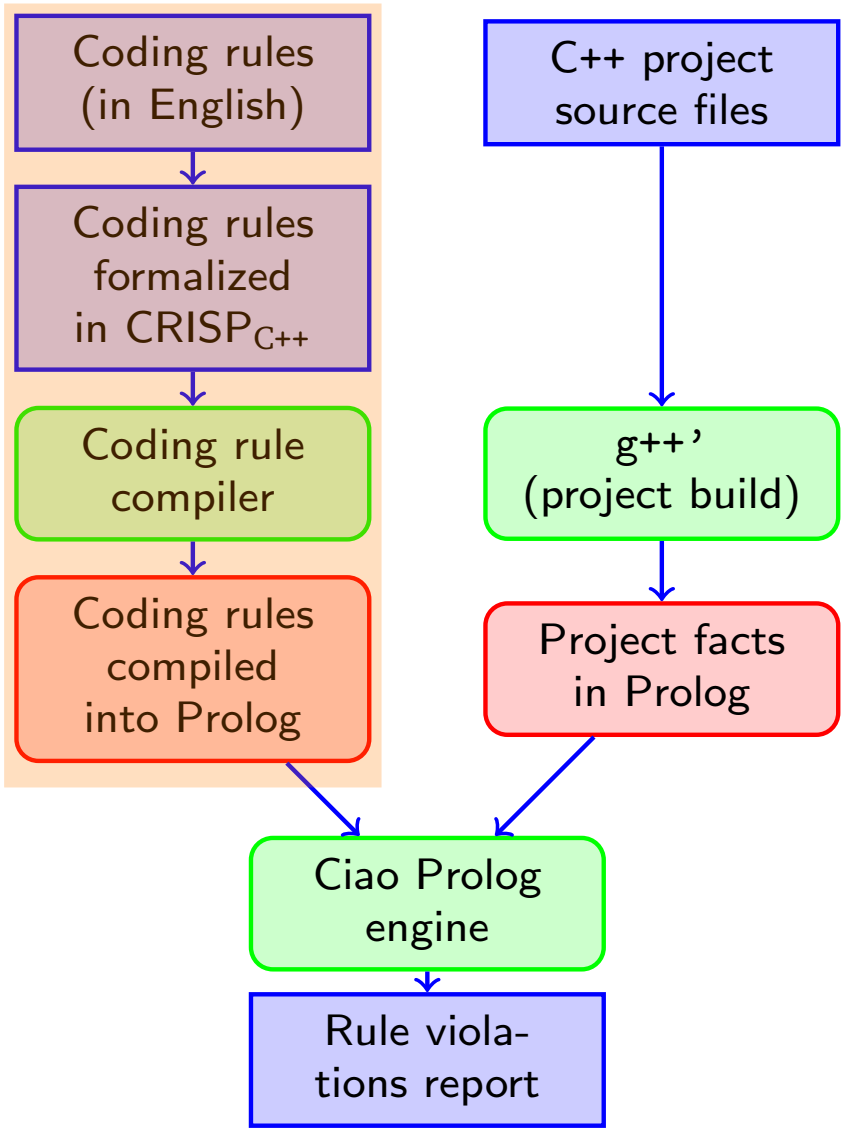

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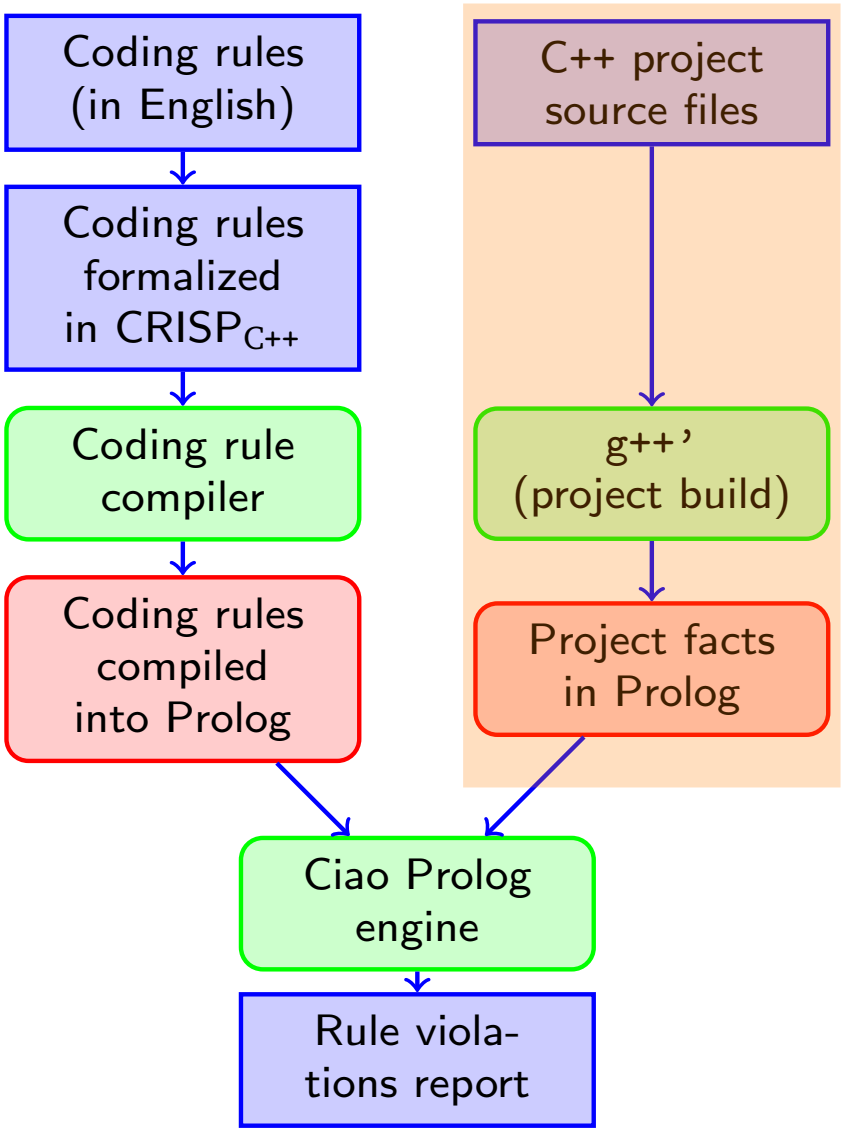

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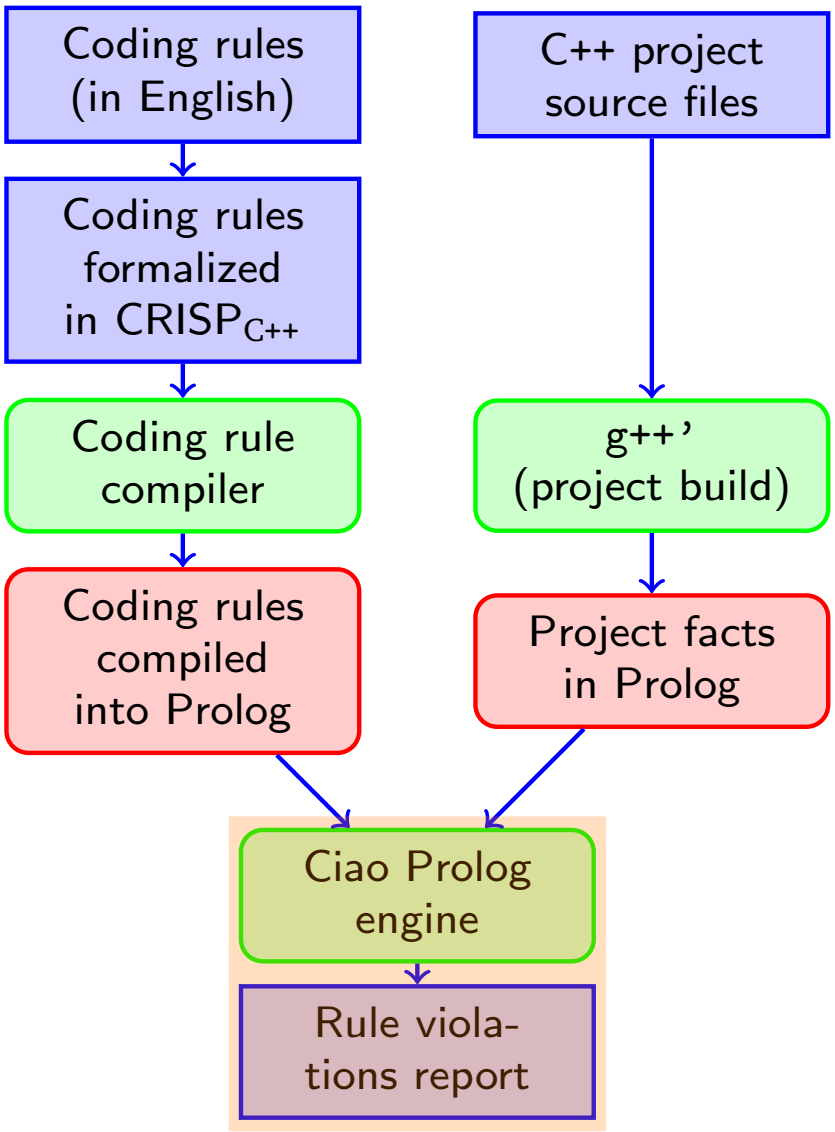

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CRISP Building Blocks 1: Sorts

Variable, DataMember, LocalVariable
Function, MemberFunction, Constructor
Type, PointerType, Record
Scope, Namespace, Record, CompoundStatement
Operator
ArgumentTypeInFunctionType
ClassMember
Thing

CRISP Building Blocks 2: (Binary) Relations

Function	*calls*	Function
Record	*hasImmediateBase*	Record
Variable	*hasType*	NonFunctionType
Function	*hasType*	FunctionType
Thing	*isDefinedIn*	Scope
Scope	*isNestedIn*	Scope
Record	*hasMember*	MemberFunction
Record	*hasMember*	DataMember
Record	*hasBase*	Record
Record	*isPrivateBaseOf*	Record
Record	*isVirtualBaseOf*	Record
PointerType	*hasPointedType*	Type
FunctionType	*hasReturnType*	Type
Record	*hasFriend*	Record
Record	*hasFriend*	MemberFunction
ClassMember	*hasVisibility*	Visibility

Example of Rule Formalization

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```
rule          HICPP 3.3.13'
violated by   Caller : MemberFunction; Callee : VirtualFunction
when          exists R : Record such that
              (
                    R hasMember Caller
                and R hasMember Callee
                and
                (
                    Caller is Constructor
                    or Caller is Destructor
                )
                and Caller calls+ Callee
              )
.
```

Auxiliary Sorts and Relations

```
relation    F : Function oveloads F' : Function
when        exists S : Scope ; N : String such that
            (
                    F  isDefinedIn S
                and F' isDefinedIn S
                and F  hasUnqualifiedName N
                and F' hasUnqualifiedName N
                and F \= F'
            )
.
```

```
sort        M : ClassMember is PrivateClassMember
when        exists V : Visibility such that
            (
                M hasVisibility V and V is 'private'
            )
.
```

Integration into GCC

- GlobalGCC Project (Eureka/ITEA). Enhance the GNU compiler collection with:
  - Project-wide static analysis
  - Global optimization
  - Coding rule checking
- Huge potential user base
- All facts of a project in a single file
- User interface. Two steps:
  1. `g++ -fipa-codingrules -fipa-codingrules-file=FILENAME`

     Pass appropriate `CXX` to `./configure`
  2. `checkrules -s RULE_SET [-r RULES] FILENAME`

Code available at `http://www.ggcc.info`

Experimental Results

Project	KLoc	Load Time	# Violations (Checking Time)			
			3.3.1	3.3.2	3.3.11	3.3.15
Bacula	20	0.24	0 (0.0)	3 (0.0)	0 (0.0)	0 (0.0)
CLAM	46	1.62	1 (0.0)	15 (0.5)	115 (0.1)	0 (0.2)
Firebird	439	2.61	16 (0.0)	60 (1.0)	115 (0.2)	0 (0.3)
IT++	39	0.42	0 (0.0)	6 (0.0)	12 (0.0)	0 (0.0)
OGRE	209	3.05	0 (0.0)	15 (0.9)	79 (0.2)	0 (0.3)
Orca	89	1.17	1 (0.0)	12 (0.4)	0 (0.1)	0 (0.2)
Qt	595	10.42	15 (0.0)	75 (10.5)	1155 (1.3)	4 (1.2)

All times expressed in seconds.

Work in Progress

1. Implement / Enrich the CRISP Language
2. Implement more rules with information given by other tools
3. Open our abstract representation of programs to external tools

Implement / enrich the CRISP language

- Quantification and true negation needed
  - Both performed over certain domains (sorts)
  - Infinite domains may appear with templates / generics
  - We have an implementation of constructive intensional negation
- Goals automatically reordered
- Extend CRISP to other languages: Java, Ada, C, Fortran, ...

Examples of Rules that Need Specific Analysis

Rule HICPP 3.3.13:

"Do not invoke virtual methods of the declared class in a constructor or destructor."

Rule HICPP 3.2.5:

"Ensure destructors release all objects owned by the object"

Rule HICPP 3.4.2:

"Do not return non-const handles to class data from const member functions"

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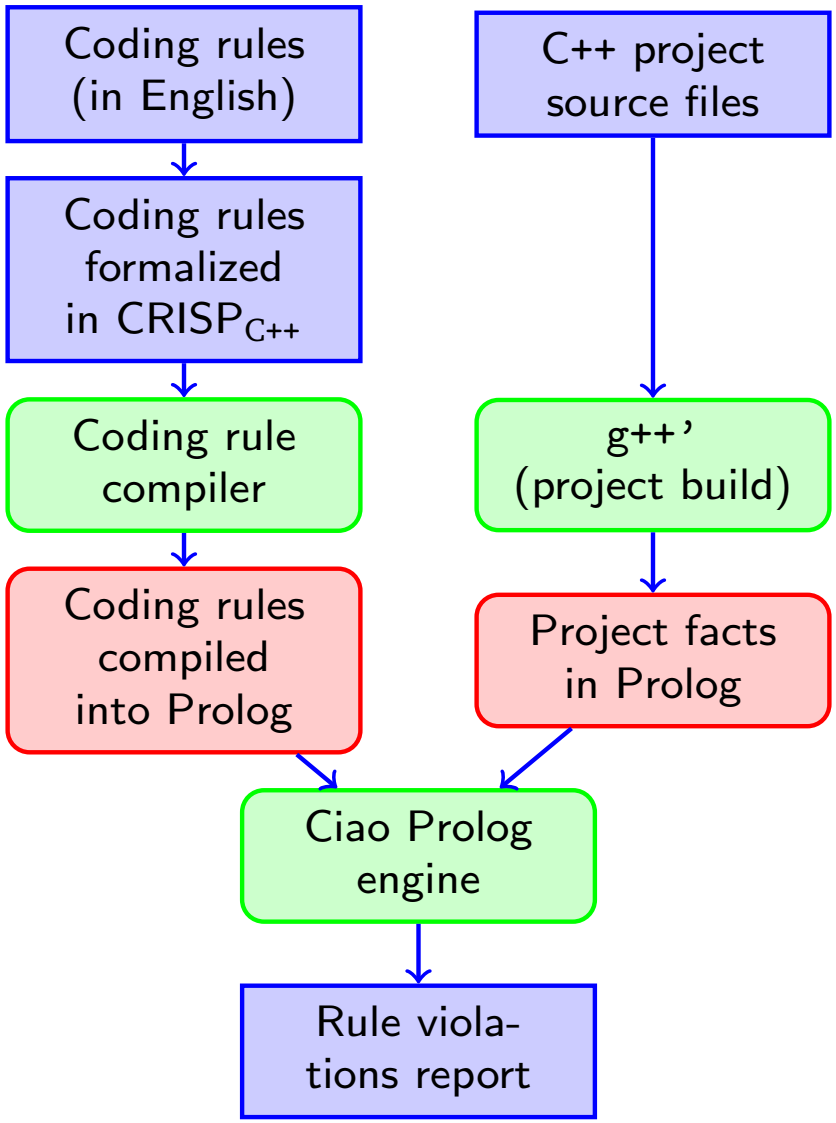
Integration of Information from External Analyzers



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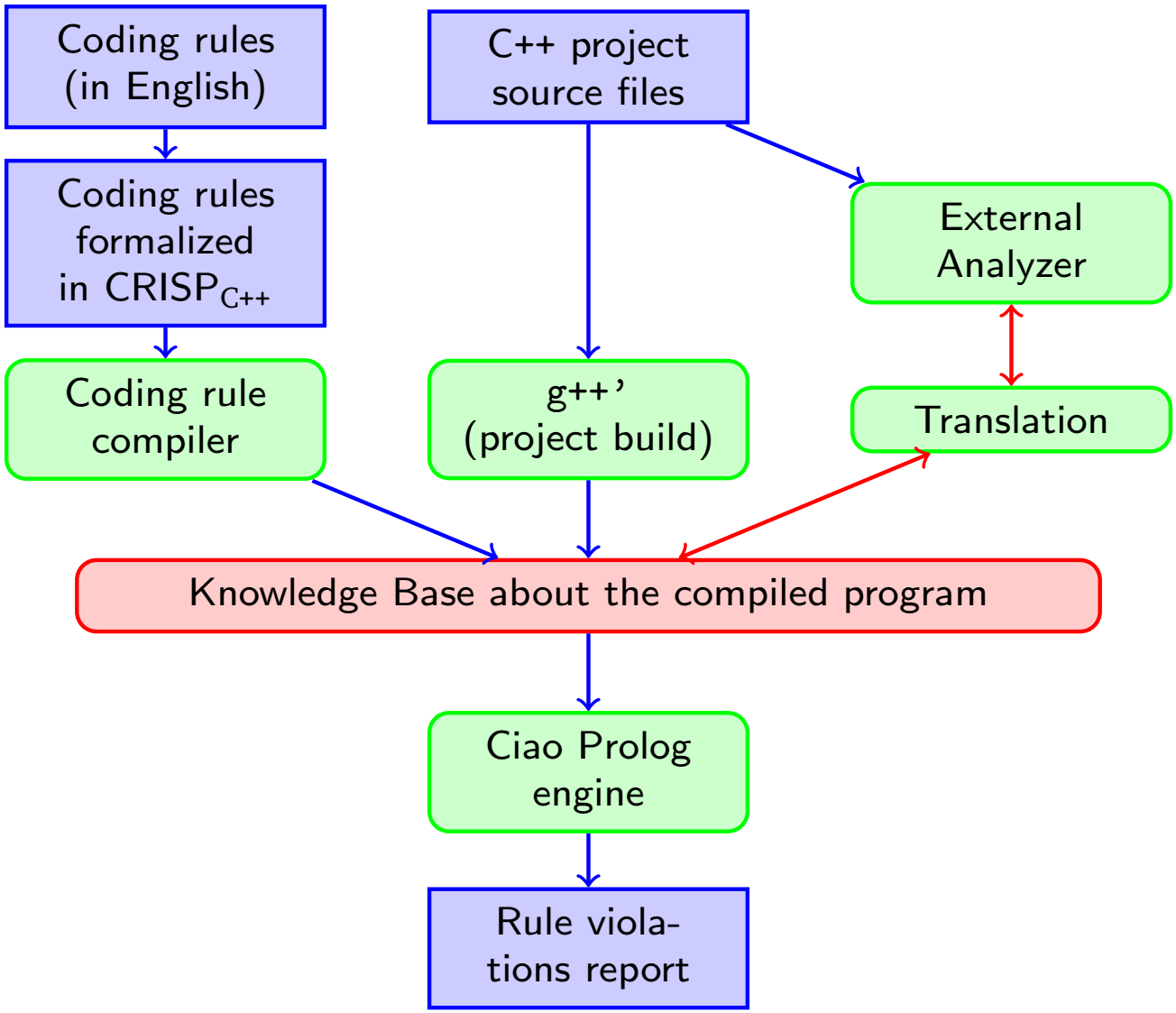
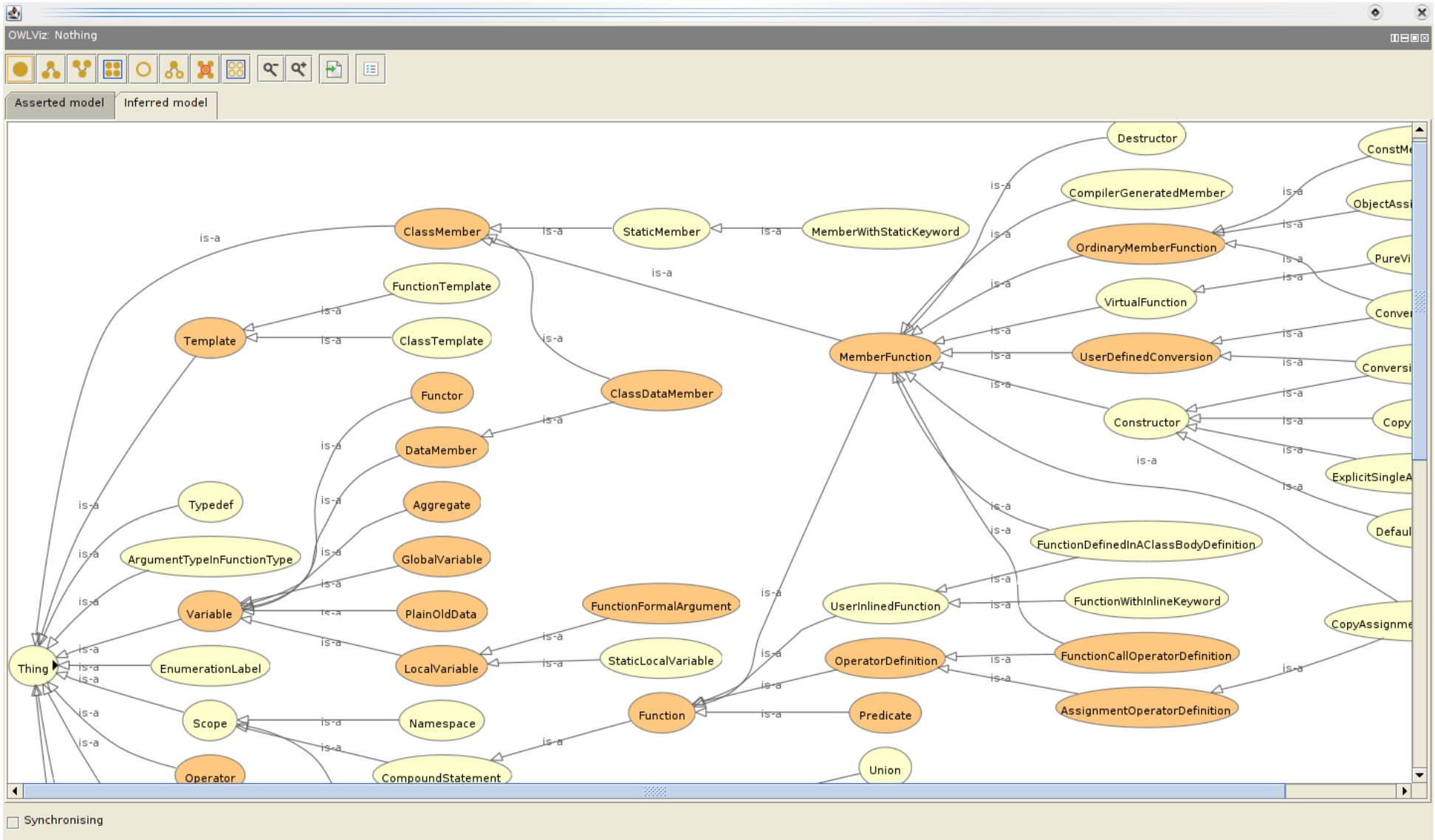


Open the Knowledge Base to External Tools



Thanks for your Attention!

- Questions?
- Comments?