C++ Semantic Interface:
Idea, Architecture, Implementation

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Outline

- The idea
- Related projects
- Semantic representation
- Advanced search model
- XML representation
- Implementation & current state

The idea of C++ Semantic API

The main idea is to provide researchers and programmers with a **powerful, flexible and extensible platform** for creating wide range of language-related tools and applications

(A research task) To experiment with separating C++ syntax from its semantics

(A research task) To experiment with using XML for representing C++ semantics

Related Projects

ASIS

Ada **S**emantic **I**nterface **S**pecification (for Ada95): the ISO standard

SAGE - SAGE II - ROSE (for C/C++, HPF…)

An open compiler infrastructure for source-to-source transformations

Pivot (for C++)

Stroustrup & Dos Reis; "General infra-structure for transformation and static analysis of C++ programs"

Some others…

Advantages of the project presented

Extensibility

Both source language and semantic representation are extendable

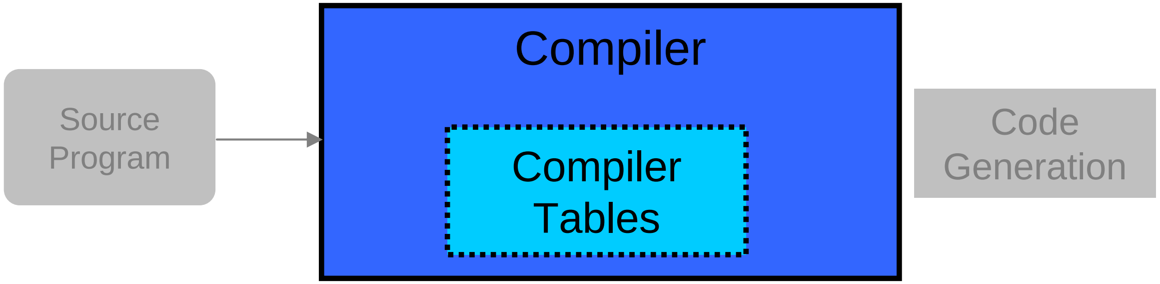
Semantic search feature

Powerful mechanism for investigating programs (including program comparisons)

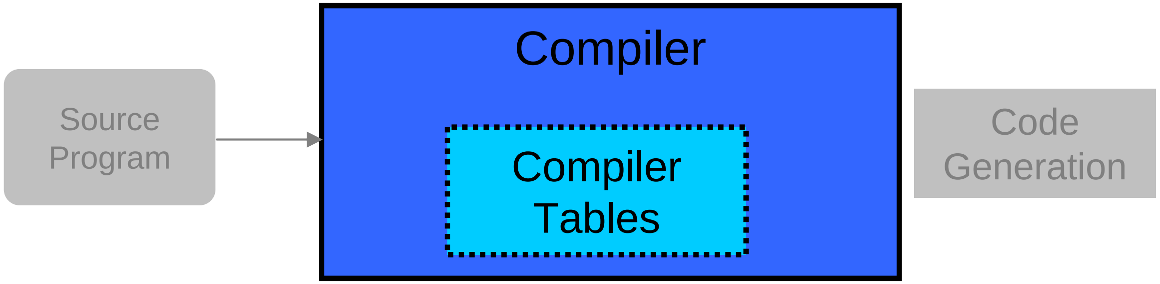
Doesn't depend on a third-party front-end

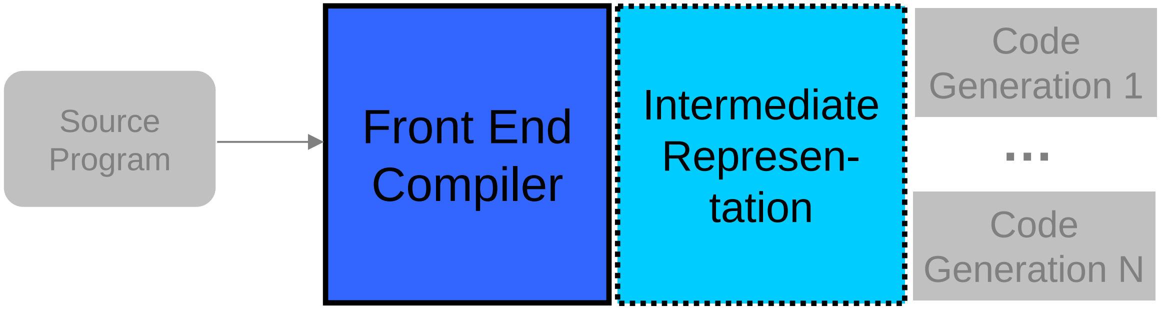
Comprises parsing routines with name resolution, type checking etc.

The Evolution of the Compiler Architecture 1

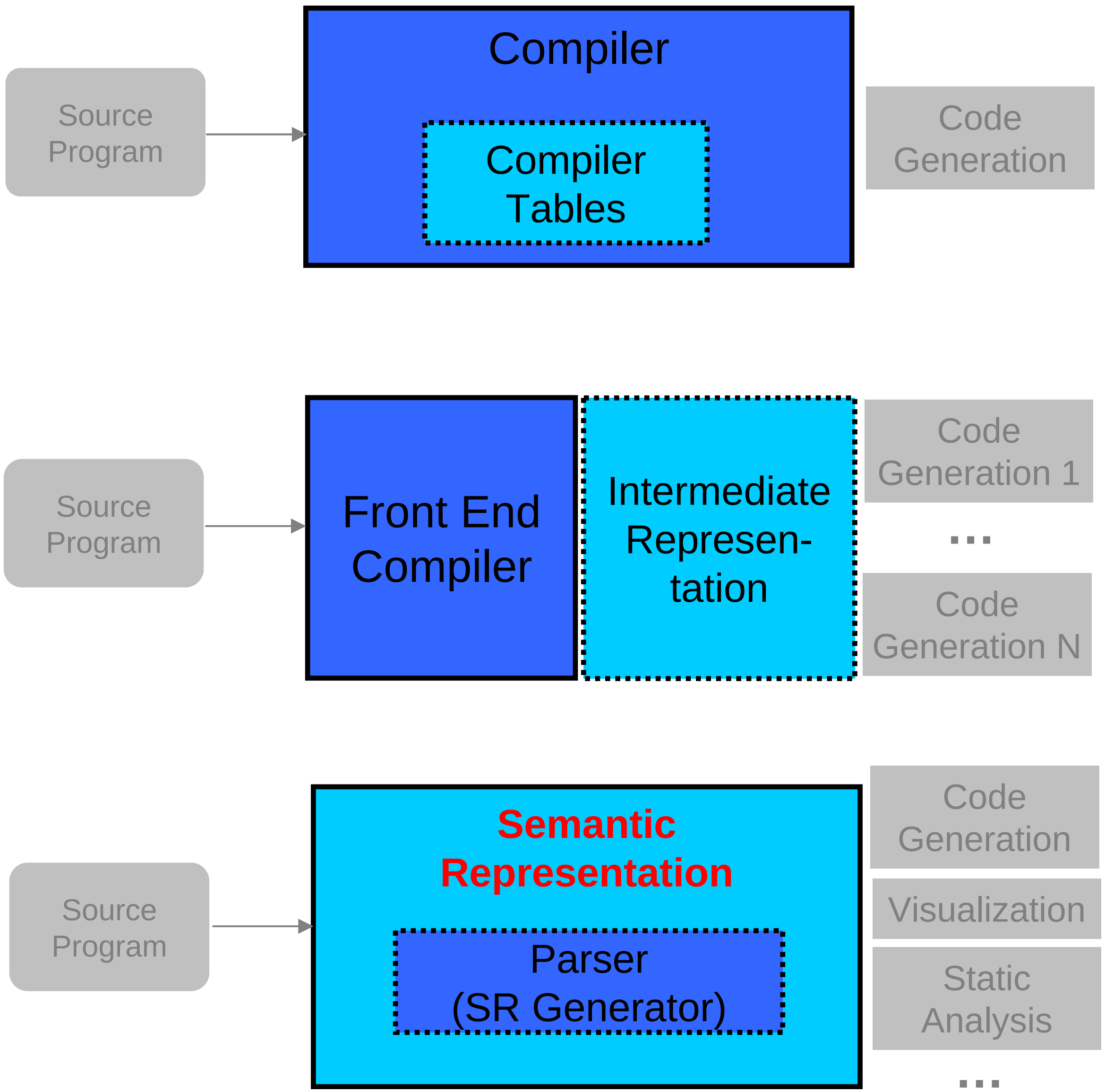


The Evolution of the Compiler Architecture 2

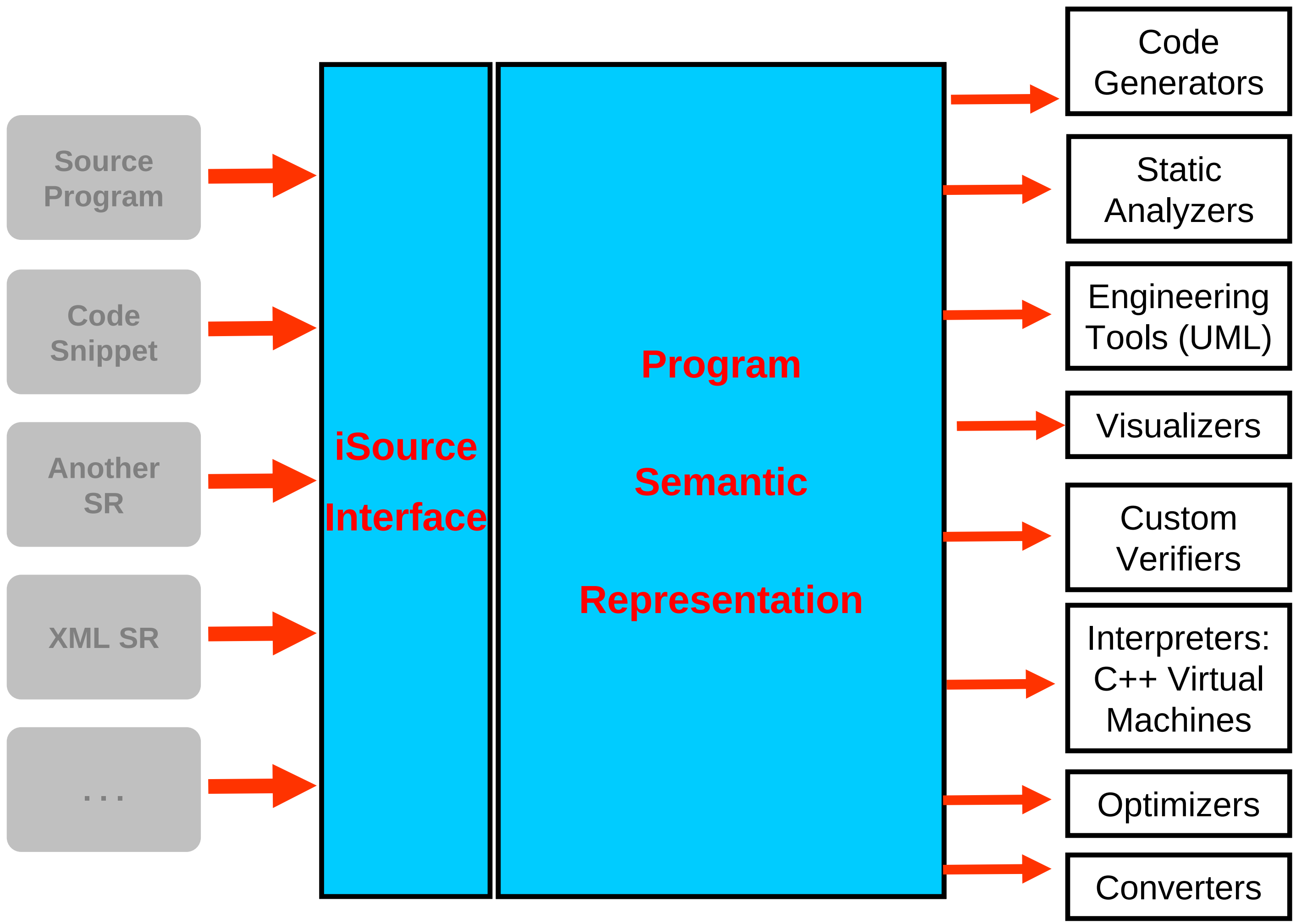




The Evolution of the Compiler Architecture 3



SemantiC++: Common Scheme



SemantiC++: Basic Principles

A rich set of classes each of which represents a particular C++ language notion (class, statement, operator, operand etc.)

The relationships between classes (inheritance, aggregation, delegation) reflect conceptual relationships between corresponding language notions

For a source program, class instances compose an Abstract Syntax Tree for that program

SemantiC++: Basic Principles 2

This is not just a structure (like CCI): every class has a functionality for typical operations on ASTs (examples follow)

This is not just a syntax structure: every class has a set of attributes which represent various semantic properties of the notion ("annotated AST")

There is not just 1-to-1 correspondence between source and AST:
hidden semantics is represented explicitly (destructor calls, operator function calls)

SemantiC++: Inheritance Class Diagram

```
ENTITY
    EXPRESSION
        PRIMARY
        POSTFIX_EXPRESSION
            ...
        UNARY_EXPRESSION
            ...
    STATEMENT
        EXPRESSION_STATEMENT
        COMPOUND_STATEMENT
            TRY_BLOCK
            SELECTION_STATEMENT
    TYPE
        FUNDAMENTAL
            ...
        MODIFIER
            POINTER
            ...
        FUNCTION
        CLASS
        ...
```

(Indentation denotes inheritance)

SemantiC++: Example of Node (simplified)

```
class COMPOUND_STATEMENT : STATEMENT, iSCOPE {
    // Structure
    public LIST<STATEMENT> statements;
    public LIST<DECLARATION> declarations;
    // Creation
    protected COMPOUND_STATEMENT() ...
    public static COMPOUND_STATEMENT create() ...
    // Opening
    public static COMPOUND_STATEMENT open
                ( iSource source, iSCOPE context )...
    // Validation
    public override bool check() ...
    public override bool validate() ...
    // Semantic search
    public static COMPOUND_STATEMENT pattern =
                       COMPOUND_STATEMENT.create();
    public override bool match ( ENTITY pattern ) ...
    // Attributes
    public ENTITY owner;
    public bool isValid, isChecked, isGenerated;
}
```

Example of a Class: Some Comments

create(): a way to create a node/subtree from scratch

open(): a common means for reading node or subtree from outside: in particular, from a source text!

check(), validate(): check structural and semantical correctness of the node/subtree

match(): checks whether this node matches the parameter

pattern: common pattern for this node: matches ANY compound statement

SemantiC++: Example of an AAST (simplified)

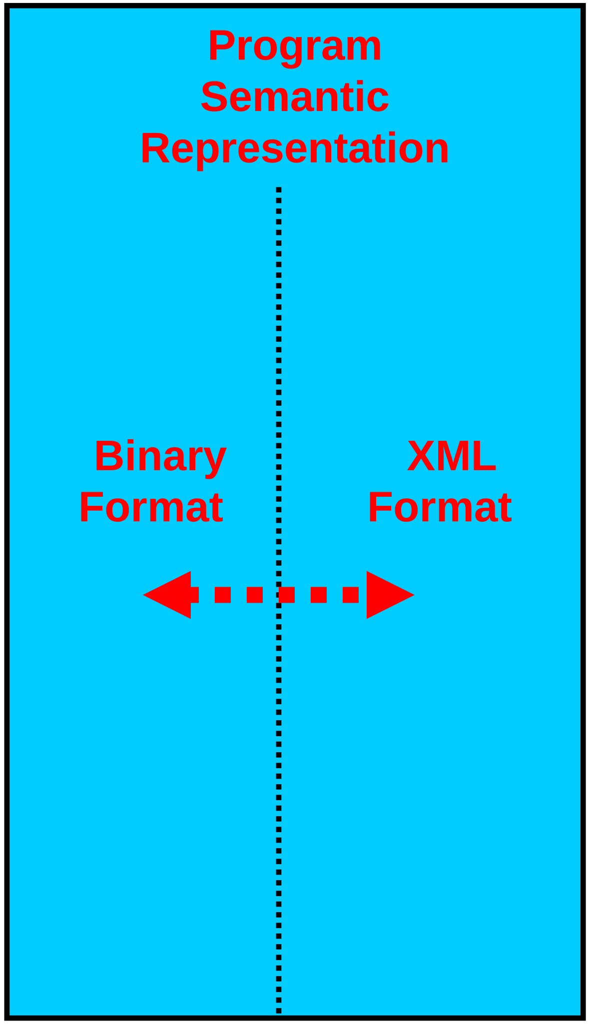
SemantiC++: Schematic Examples of Use

```
using Semantic;
...
class Example {
  static void Main() {
    NAMESPACE_DECL ns =
           NAMESPACE_DECL.create(IDENT.create("N"));

    CLASS_DECL cls = CLASS_DECL.open(   // Opening
                    new FileSource("full-file-name"),ns);
    if ( cls == null || !cls.validate() )
    {   /* errors in class declaration */ }

    string source = "int main()                 " +
                    "{ cout << \"Hello world!\";" +
                    "  return 0; }              ";
    FUNCTION_DECL main = FUNCTION_DECL.openSource(
                    new TextSource(source),ns);
    ns.add(cls,main);
    if (ns.validate()) ns.execute();  // ☺
  }
}
```

Binary and XML Formats: Two Faces of the Same



Both formats have the same rights (both are “first class citizens”)

Both formats are inter-changeable

Internally there are conver-verters Binary->XML & XML->Binary

Why XML?

- Open format
- Extensible
- Extremely simple model
- De-facto standard
- Lots of tools & technologies (e.g. XQuery, XSLT) to manipulate on

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- Open format
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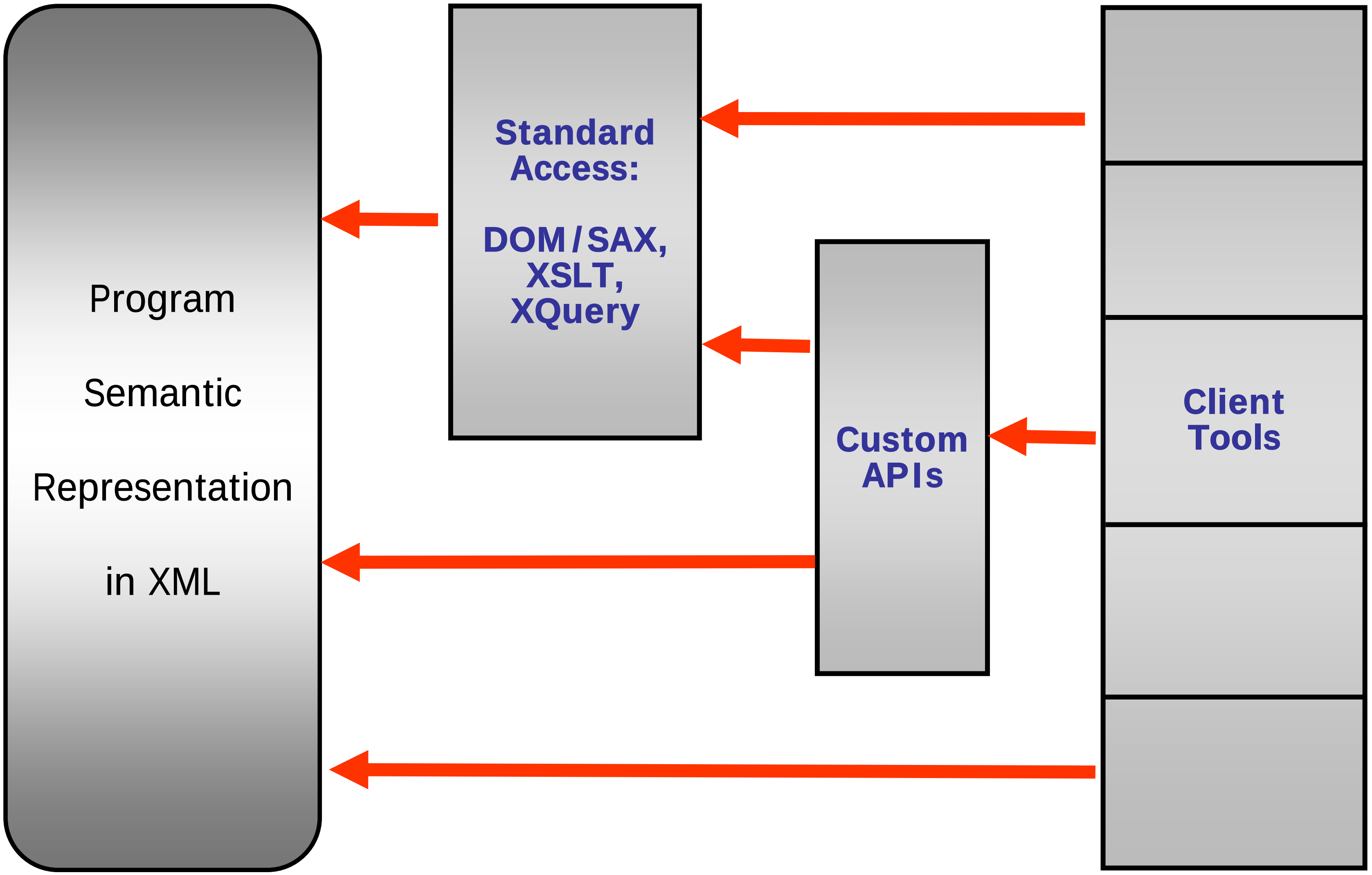
- Lots of tools & technologies (e.g. XQuery, XSLT) to manipulate on
- (Hidden idea ☺) To experiment with XSLT technology: is it applicable and useful to manipulate with C++ semantic representation (in XML form)?

Example of the XML representation (simplified)

```
while ... {
   x = ...;
   P(...);
}
```

```
<while-statement ln="1" col="1">
    <condition>
        <expression ln="1" col="7"> ... </expression>
    <condition>
    <compound-statement>
        <assignment-expression ln="2" col="4">
            <name ln="2" col="4">x</name>
            <expression ln="2" col="9"> ... </expression>
        </assignment>
        <call ln="3" col="4">
            <name ln="3" col="4">P</name>
            <argument-list>
                <expression ln="3" col="5"> ... </expression>
            </argument-list>
        </call>
    </compound-statement>
</while-statement>
```

XML Based Architecture



Semantic Search

Implementation Approach

The project is being implemented on top of .NET in C#: faster programming, easier to maintain, more reliable code

Interoperability: the SR is accessible from any .NET language (Managed C++, C#, VB, F#, Python, Zonnon)

All SR components have the form of .NET DLL libraries and can be attached to client programs in the standard way ("using xxx.dll")

Current state of the project

"Semantic" classes,
semantic search -
completely implemented (not tested yet)

Opening routines for sources (parsing),
XML Schema for semantic representation -
are being developed

Client tools: (Re)engineering tool for UML -
is being developed

Beta testing -
planned…

Questions?
Critique?

JAXT - Java Axiom Testing