



Writing C Rules Using RuleChecker Tcl Verifier

Before using this information, be sure to read the general information under “Notices” section, on page 29.

This edition applies to **VERSION 6.6**, *IBM RATIONAL LOGISCOPE* (product number 5724V81) and to all subsequent releases and modifications until otherwise indicated in new editions.

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About this manual

This manual is a complement to the *IBM Rational Logiscope RuleChecker & QualityChecker – C Reference Manual* where the **Tcl Verifier** data model and main support procedures are described.

Reading first the above document is mandatory.

What is important to remember is that the data model mainly describes an abstract syntax tree of the code, with some semantic information already resolved and attached to the syntax tree.

Audience

This manual is intended for **IBM® Rational® Logiscope™ RuleChecker C** users who want to verify new programming rules using the **Tcl Verifier** and develop the associated scripts.

Overview

This document describes some fine points and how C constructs translate to the data model used by the Logiscope **Tcl Verifier**.

Section 1 explains some key support procedures of the **Tcl Verifier**.

Section 2 gives examples of how C code is translated into the data model.

Section 3 provides usual shortcuts when using the **Tcl Verifier**.

Section 4 addresses some special cases.

Conventions

The following typographical conventions are used in this manual:

<i>italics</i>	names of textual elements (filename), notes, documentation titles.
typewriter	screen and file examples.

Contacting IBM Rational Software Support

If the self-help resources have not provided a resolution to your problem, you can contact IBM® Rational® Software Support for assistance in resolving product issues.

Note. If you are a heritage Telelogic customer, you can go to <http://support.telelogic.com/toolbar> and download the IBM Rational Telelogic Software Support browser toolbar. This toolbar helps simplify the transition to the IBM Rational Telelogic product online resources. Also, a single reference site for all IBM Rational Telelogic support resources is located at:

<http://www.ibm.com/software/rational/support/telelogic/>

Prerequisites

To submit your problem to IBM Rational Software Support, you must have an active Passport Advantage® software maintenance agreement. Passport Advantage is the IBM comprehensive software licensing and software maintenance (product upgrades and technical support) offering. You can enroll online in Passport Advantage from

<http://www.ibm.com/software/lotus/passportadvantage/howtoenroll.html> .

- To learn more about Passport Advantage, visit the Passport Advantage FAQs at http://www.ibm.com/software/lotus/passportadvantage/brochures_faqs_quickguides.html .
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- Be a registered user on the IBM Rational Software Support Web site. For details about registering, go to <http://www-01.ibm.com/software/support/> .
- Be listed as an authorized caller in the service request tool.

Submitting problems

To submit your problem to IBM Rational Software Support:

- 1) Determine the business impact of your problem. When you report a problem to IBM, you are asked to supply a severity level. Therefore, you need to understand and assess the business impact of the problem that you are reporting.

Use the following table to determine the severity level.

Severity	Description
1	The problem has a <i>critical</i> business impact. You are unable to use the program, resulting in a critical impact on operation. This condition requires an immediate solution.
2	The problem has a <i>significant</i> business impact. The program is usable, but it is severely limited
3	The problem has a <i>some</i> business impact. The program is usable, but less significant features (not critical to operation) are unavailable.
4	The problem has a <i>minimal</i> business impact. The problem causes little impact on operations or a reasonable circumvention to the problem was implemented.

2) Describe your problem and gather background information, When describing a problem to IBM, be as specific as possible. Include all relevant background information so that IBM Rational Software Support specialists can help you solve the problem efficiently. To save time, know the answers to these questions:

- What software versions were you running when the problem occurred?
To determine the exact product name and version, use the option applicable to you:
 - Start the IBM Installation Manager and select **File > View Installed Packages**. Expand a package group and select a package to see the package name and version number.
 - Start your product, and click **Help > About** to see the offering name and version number.
- What is your operating system and version number (including any service packs or patches)?
- Do you have logs, traces, and messages that are related to the problem symptoms?
- Can you recreate the problem? If so, what steps do you perform to recreate the problem?
- Did you make any changes to the system? For example, did you make changes to the hardware, operating system, networking software, or other system components?
- Are you currently using a workaround for the problem? If so, be prepared to describe the workaround when you report the

problem.

3) Submit your problem to IBM Rational Software Support. You can submit your problem to IBM Rational Software Support in the following ways:

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For more information about opening a service request, go to <http://www.ibm.com/software/support/help.html> .

You can also open an online service request using the IBM Support Assistant. For more information, go to:

<http://www-01.ibm.com/software/support/isa/faq.html>

- **By phone:** For the phone number to call in your country or region, go to the IBM directory of worldwide contacts at <http://www.ibm.com/planetwide/> and click the name of your country or geographic region.
- **Through your IBM Representative:** If you cannot access IBM Rational Software Support online or by phone, contact your IBM Representative. If necessary, your IBM Representative can open a service request for you. You can find complete contact information for each country at <http://www.ibm.com/planetwide/> .

If the problem you submit is for a software defect or for missing or inaccurate documentation, IBM Rational Software Support creates an Authorized Program Analysis Report (APAR). The APAR describes the problem in detail. Whenever possible, IBM Rational Software Support provides a workaround that you can implement until the APAR is resolved and a fix is delivered. IBM publishes resolved APARs on the IBM Rational Software Support Web site daily, so that other users who experience the same problem can benefit from the same resolution.

Bibliography

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1994 ISBN 0-201-63337-X

[TCL03] BRENT WELCH, KEN JONES, JEFFREY HOBBS

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International standard Programming languages - C

1. Support Procedures

1.1. MapRole

The main support procedure is `MapRole`. The main purpose of this procedure is to allow navigation in the data model, as described in the *IBM Rational Logiscope RuleChecker & QualityChecker C Reference Manual*.

But it can also be used in other ways. The purpose of this procedure is to allow actions on the target objects of a link in the data model, but it returns a count of objects on which the action has been performed.

For example, if you want to know whether a type is qualified with `const`, you may use the fact that there is a `QualifierConst` object in the `qualifier` role of the type:

```
if {[MapRole $type qualifier -filterclass QualifierConst {expr 0;#}]}
```

Here, the action is to return 0, which stops the `MapRole` as soon as a `QualifierConst` is encountered during the navigation on the role. `;` introduces a TCL comment, so that the exact action performed, `expr 0;# <handle on qualifier>`, does not see the handles on the qualifier objects. This `MapRole` will return 0 if no action is performed (i.e. there is no `QualifierConst` object in the role), or 1 if there is at least one `QualifierConst`. The `MapRole` will stop as soon as a `QualifierConst` object is processed.

Another example: you may compute the number of operands of an `ExpressionComplex` (i.e. an expression with operator or function) with:

```
set argumentCount [MapRole $expression operand]
```

(a missing action is like having an action that always returns 1).

A filter can be inserted between the name of the link that is to be followed and the action. The filter restricts the objects that are subject of the action. Note that these objects are thus not counted in the result of `MapRole`.

The filter can be:

- `-filter <script fragment>`. The `<script fragment>` is evaluated, like the action, with the object handle appended. If the filter returns 0, the action is not evaluated; if the filter returns 1, the action is evaluated.
- `-filterclass <class list>`. The action is evaluated only if the object is an instance of one of the classes of `<class list>`.

For example, to perform an action on all expressions using the ternary operator (`? :`):

```
proc isTernary {expression} {
    expr {[isClassObject ExpressionComplex $expression] && \
        [isClassObject FunctionTernary [GetRole $expression function]]}
}
```

```
MapRole application expression -filter isTernary action
```

To count the number of `typedef` in a translation unit `$scopeTU`:

```
set typedefCount [MapRole $scopeTU symbolDef \
                 -filterclass SymbolType]
```

1.2. Violation

The other important support procedure is Violation:

```
Violation $object $::thisRule "message"
```

The global variable `thisRule` is always set to the value of the `.KEY` keyword of the rule file before evaluation of the rule code. But what is interesting here is the `$object` part: this must be an object handle, and the object must belong to a class which inherits of the class `Origin`; the object handle is used to know where (file, line, function, if applicable) the violation will be shown. So you can play tricks with it. For example, if you want to flag a non conforming identifier for a variable, it may be best to issue a violation notice on all declarations and definitions of the variable.

1.3. IsClassObject

The `isClassObject` procedure performs the same function as the `-filterclass` filter of `MapRole`: it allows to efficiently test the class of a data model object.

```
set clist {InstructionDefinition InstructionTentativeDefinition}
if {[isClassObject $clist $object]} {
    ...
}
```

is equivalent to

```
if {[lsearch -exact $clist [Class $object]] >= 0} {
    ...
}
```

except that the `isClassObject` procedure is more memory and time efficient, and that it checks the validity of the class names in `$clist`.

2. From C Code to Data Model

2.1. Scopes and Symbols

A `Symbol` is an identifier in a scope. Scope objects are name spaces for identifiers,

The identifiers visible in the whole application are in the role `symbolDef` of the `ScopeGlobal` (there may be here only instances of `SymbolVariable` and `SymbolFunction`). There is only one instance of `ScopeGlobal`.

Every C file introduces a `ScopeTranslationUnit` which is the name space representing the C file with all included files expanded. Here are `SymbolVariable` and `SymbolFunction` declared with the keyword `static`, `SymbolType` (`typedef` identifiers), `SymbolTag` (tags of structures, unions and enumerations) and `SymbolEnum` (enumeration constant) that are declared at file level, and all `SymbolMacro` encountered in the C file and the included files.

Every structure and union introduces a new name space, represented by a `ScopeStructure`, that contains the `SymbolField` (field identifiers).

Every defined function introduces a new name space (`ScopeFunction`), that contains the parameter identifiers (of class `SymbolVariable`) and the `goto` labels (`SymbolLabel`).

Every macro function introduces a new name space (`ScopeFunction`), that contains the parameter identifiers (`SymbolVariable`). Note that the `Variable` objects linked to these parameters have no `type` role.

Every block of instructions introduces a new name space (`ScopeBlock`), that contains all the identifiers declared and defined in the block.

The `Scope*` objects, besides holding `Symbol*` objects in the `symbolDef` role, also hold the `Variable` (`variableDef` role) and `Function` (`functionDef` role) objects which are valid within the scope: functions being either `extern` or `static`, their containing scope may only be the `ScopeGlobal` or a `ScopeTranslationUnit`; `Variable` objects may be `automatic`, `extern` or `static`, thus their containing scope may be a `ScopeBlock`, the `ScopeGlobal` or a `ScopeTranslationUnit`, respectively. Note that `static` block variables are represented by a `Variable` object in a `ScopeBlock`, with the attribute `permanent` set to `true`.

`Scope*` objects also hold the declarations and definitions of the variables and functions in the `instructionDef` role. The `InstructionDeclaration` (for variables and functions), `InstructionDefinition` and `InstructionTentativeDefinition` (for variables) are described below.

```

/* The C file (and all its includes) introduces a
   ScopeTranslationUnit */
struct { /* Introduces a new ScopeStructure,
         subScope of the ScopeTranslationUnit */
    int a; /* a SymbolField (name = "a") within the ScopeStructure */
}
/* A SymbolVariable within the ScopeTranslationUnit */
static int a;

```

```

/* A SymbolVariable within the ScopeGlobal */
extern int b = 3;
/* A SymbolFunction within the ScopeGlobal */
/* The parameter list introduces a new ScopeFunction,
   subScope of the ScopeGlobal, since the function is external */
void f(int c) {
    /* The body of the function introduces a new BlockScope */
    /* Same Variable object as above but different Symbol,
       this one being in the BlockScope */
    extern int a;
    {
        /* another BlockScope, the superScope of which is
           the previous BlockScope */
        /* same Variable object as above but different Symbol */
        extern int b;
    }
}

```

2.2. Types

Types come in different flavors:

- Built in types, represented by the classes TypeVoid, TypeInt, etc.
- Constructed types, such as pointers, arrays and function types.
- Enumeration types.
- Structure and union types.
- Symbolic types, defined with typedef.

TypeMeta may not be encountered in an instantiation of the data model.

The instantiation of the data model for the different types is illustrated below.

```
int a[5];
```

(only the type of a is represented here, not the whole declaration)



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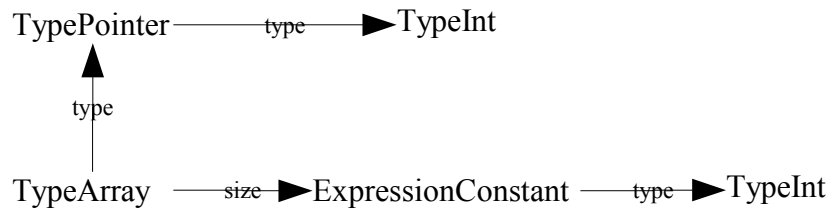
```
int a[3][2];
```

(only the type of a is represented here, not the whole declaration)



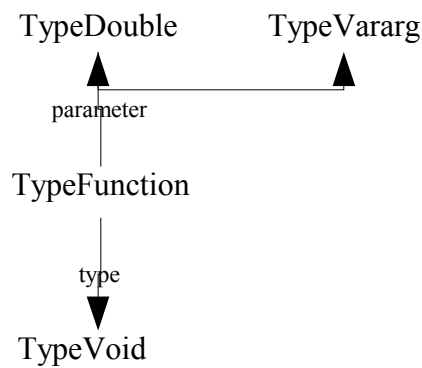
```
int *a[5];
```

(only the type of a is represented here, not the whole declaration)

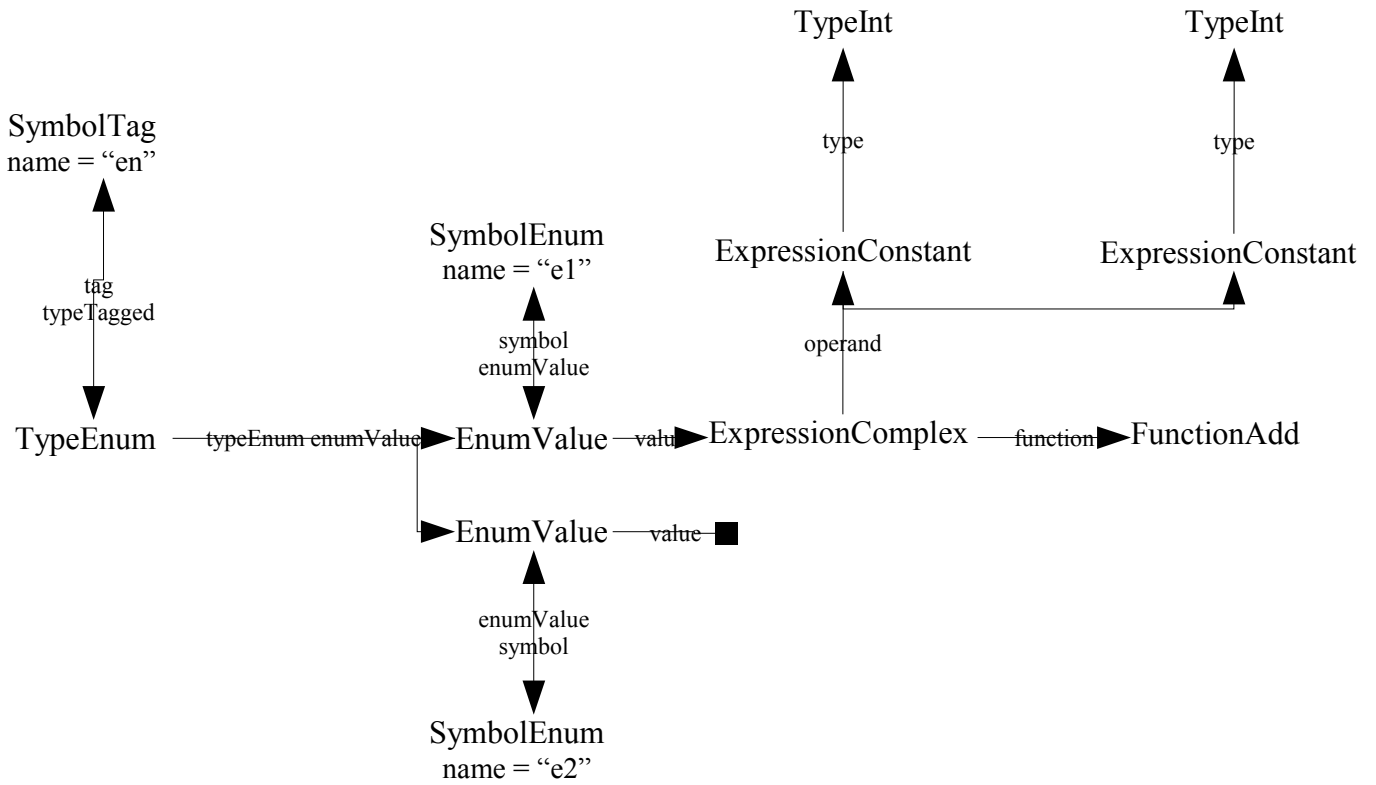


```
extern void f(double d, ...);
```

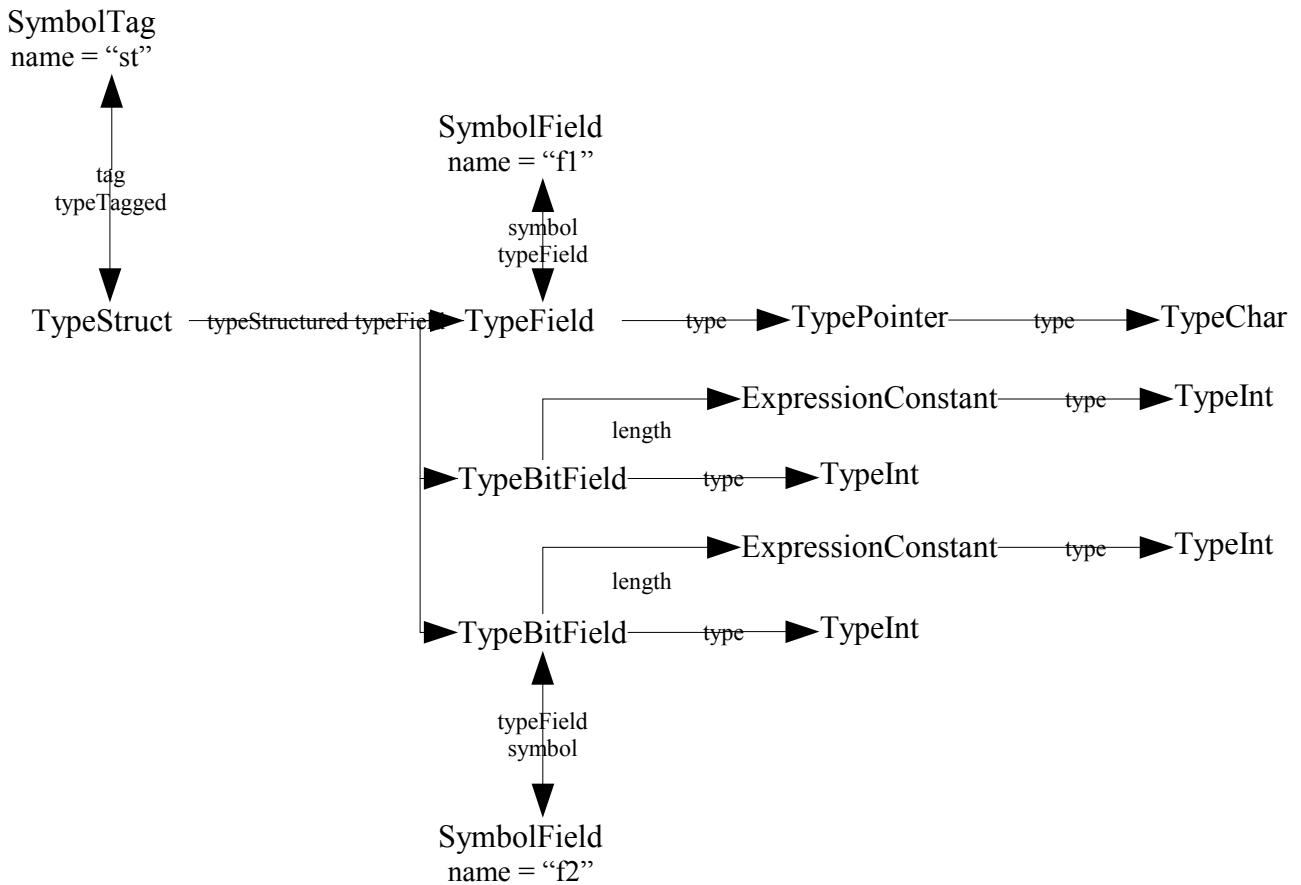
(only the type of f is represented here, not the whole InstructionDeclaration)



```
enum en {
    e1 = 3 + 4,
    e2
};
```



```
struct st {
    char *f1;
    int :2;
    int f2:6;
};
```



Note that the data model cannot distinguish between:

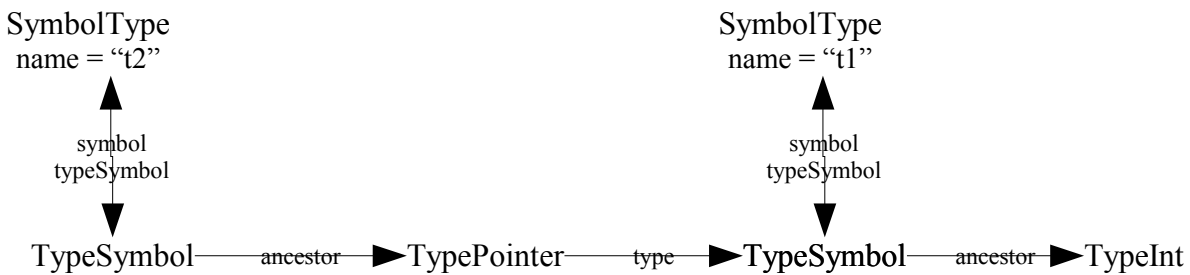
```
struct st {
    char *f1;
    int :2;
    int f2:6;
};
```


and:

```
struct st {
    char *f1;
    int :2, f2:6;
};
```

Beware that the names `TypeField` and `TypeBitField` may be confusing: their instances are not types, but fields of structures and unions.

```
typedef int t1; typedef t1 *t2;
```



(note that the role `expansion` does not work).

2.3. Function Declaration and Definition

Function objects have `InstructionDeclaration`, but no `InstructionDefinition`, nor `InstructionTentativeDefinition`.

As may be expected, an `InstructionDeclaration` is created when

```
extern int function(int i);
```

is encountered in the code. The `InstructionDeclaration` object is linked to the `SymbolFunction`, which has `function` as attribute name. By following the link from the `SymbolFunction` object to the `Function` object, all other `SymbolFunction` objects for the same function may be retrieved, and thus all the declarations for the function.

Retrieving the function definition and code is a bit trickier, and is covered below.

As a special case,

```
extern int f(void), g(int i);
```

creates two `InstructionDeclaration` objects, one for `f` and one for `g`.

2.4. Variable Declaration and Definition

Variable objects have `InstructionDeclaration`, `InstructionDefinition`, and `InstructionTentativeDefinition`.

`InstructionDefinition` objects are created for every declaration of a variable that reserves memory for the variable:

- Every variable declaration with an initializer.
- Every variable declaration in a block that is not introduced with the keyword `extern`.

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`InstructionDeclaration` objects are created for every declaration of a variable that cannot reserve memory for the variable:

- Every variable declaration without initialization that is introduced with the keyword `extern`.

All other variable declarations are represented by a `InstructionTentativeDefinition` object. It is an obscure feature of the C language that such declarations do not reserve memory for the variable by themselves: if no definition is found for the variable at the end of the translation unit, the C compiler will reserve memory for the variable. A common extension found in C compilers on UNIX systems allows the linker to merge the memory allocated by the compiler for the different tentative definitions of the same variable name with external linkage.

Most of the time, `InstructionTentativeDefinition` objects are to be used like `InstructionDefinition` objects in rules.

When several variables are declared or defined in the same statement, one `InstructionDeclaration`, `InstructionDefinition` or `InstructionTentativeDefinition` object is created for each variable.

Examples:

```
static int a;      /* InstructionTentativeDefinition */
int b;            /* InstructionTentativeDefinition */
extern int c;     /* InstructionDeclaration */
extern int b = 3; /* same b, InstructionDefinition */
int a = 4;       /* same a, InstructionDefinition */
void f(void) {
    extern int a; /* same a InstructionDeclaration */
    int d, e;    /* two InstructionDefinition */
}
```

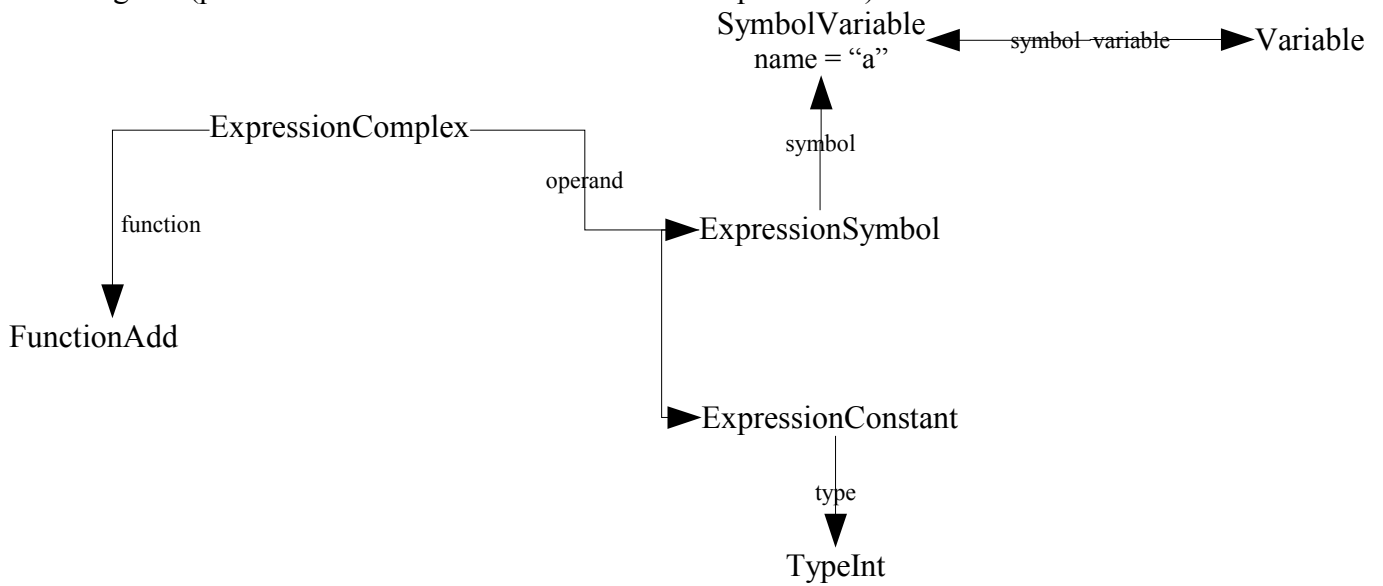
2.5. Expressions

Expressions come in different flavors:

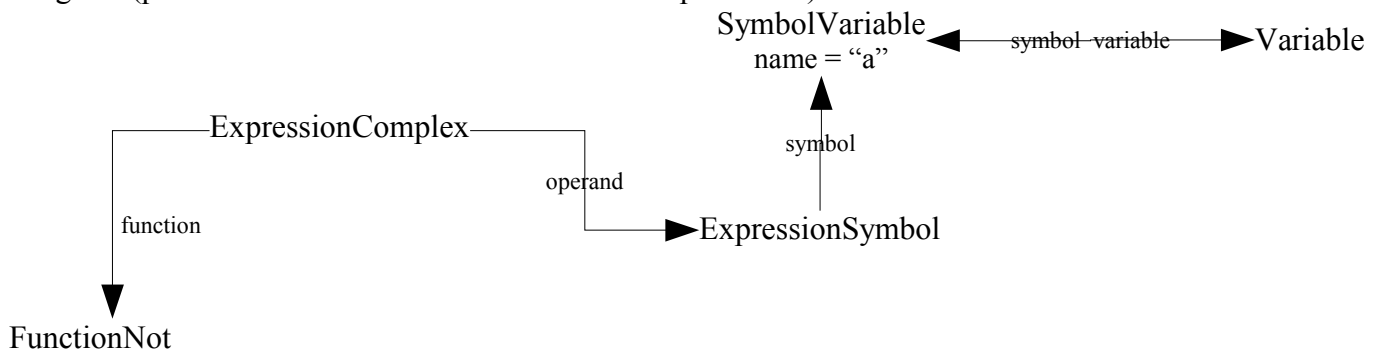
- `ExpressionConstant` represents the literal constant (numeric or string).
- `ExpressionSymbol` represents the symbolic expressions, such as a variable name, a function name, an enumeration value name, a structure or union field name.
- `ExpressionType` represents a type, when used in an expression, as part of a `sizeof` argument or in a cast.
- `ExpressionComplex` represents an expression with an operator and its operands, or a function call.

All expressions, with built in operators or function call follow a unified model. Here are two examples, the first with a binary operator, the second with a unary operator:

a + 3 gives (provided that a is a variable or a function parameter):



! a gives (provided that a is a variable or a function parameter):



The data model is analogous for all unary and binary operators, only the function differs:

Table 1 Arithmetic operators

<i>Operator</i>	<i>Class</i>
+ (unary)	FunctionPlus
- (unary)	FunctionMinus
+	FunctionAdd
-	FunctionSub
*	FunctionMul
/	FunctionDiv
%	FunctionMod

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Table 2 Bitwise operators

Operator	Class
>>	FunctionRsh
<<	FunctionLsh
&	FunctionBand
	FunctionBor
^	FunctionBxor
~	FunctionBnot

Table 3 Relational and logical operators

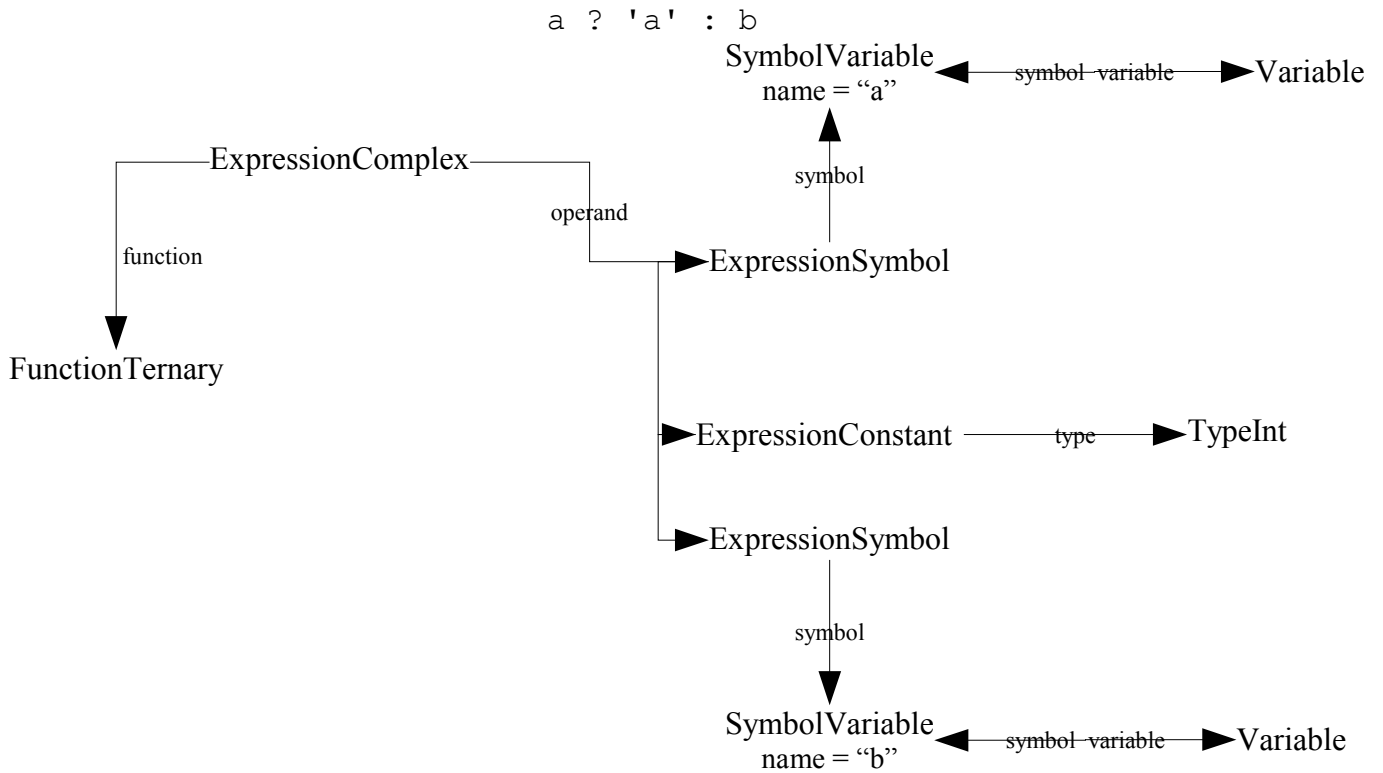
Operator	Class
<	FunctionLt
<=	FunctionLe
>	FunctionGt
>=	FunctionGe
==	FunctionEq
!=	FunctionNe
&&	FunctionAnd
	FunctionOr
!	FunctionNot

Table 4 Assignment operators

Operator	Class
=	FunctionAssign
+=	FunctionAddAssign
-=	FunctionSubAssign
*=	FunctionMulAssign
/=	FunctionDivAssign
%=	FunctionModAssign
>>=	FunctionRshAssign
<<=	FunctionLshAssign
&=	FunctionBandAssign
=	FunctionBorAssign
^=	FunctionBxorAssign
++ (prefix)	FunctionPreInc
++ (postfix)	FunctionPostInc

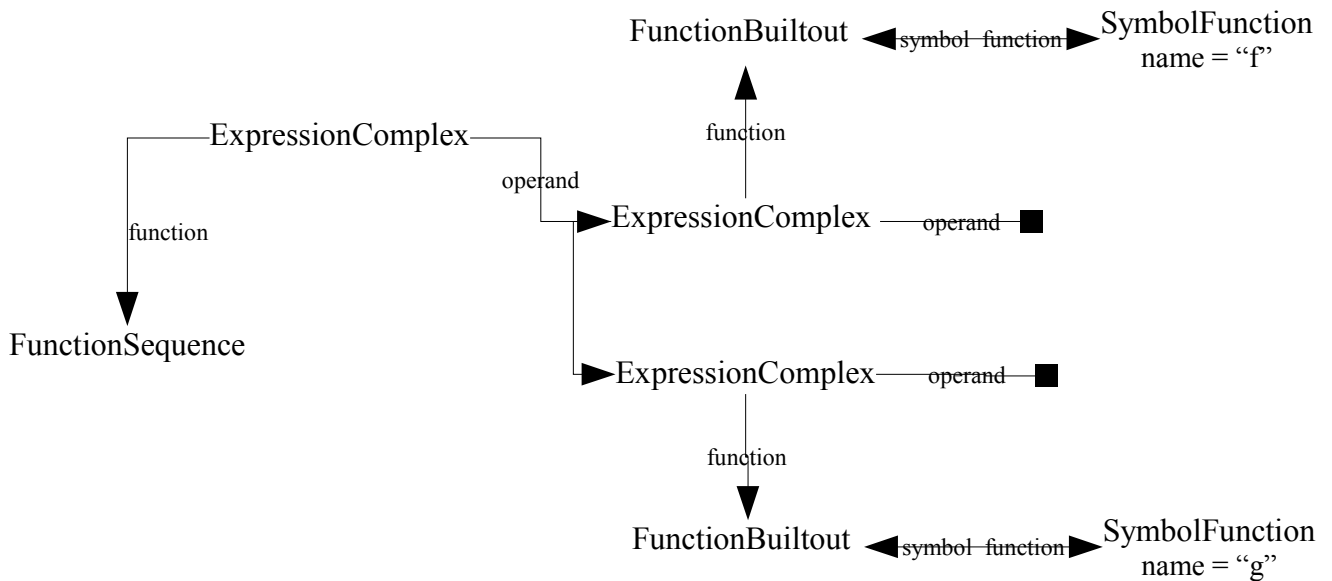
<i>Operator</i>	<i>Class</i>
-- (prefix)	FunctionPreDec
-- (postfix)	FunctionPostDec

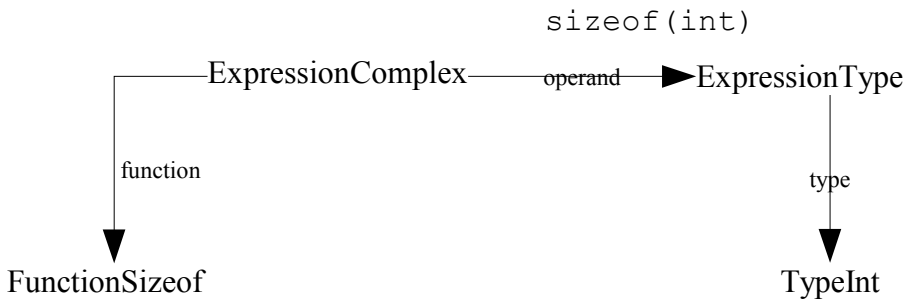
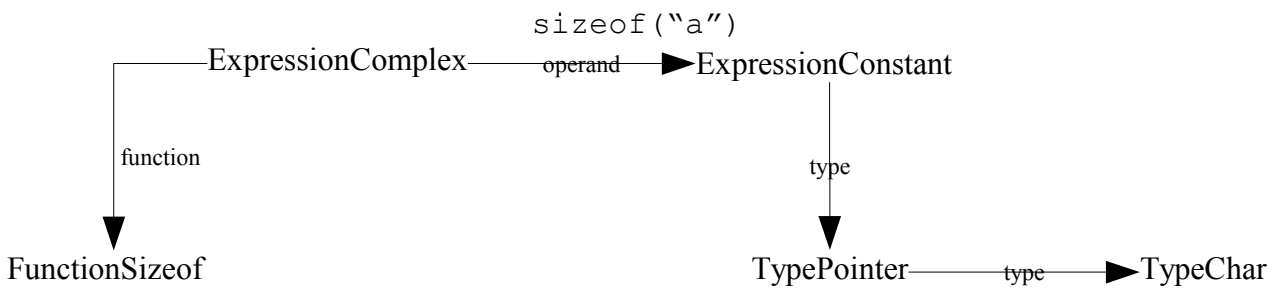
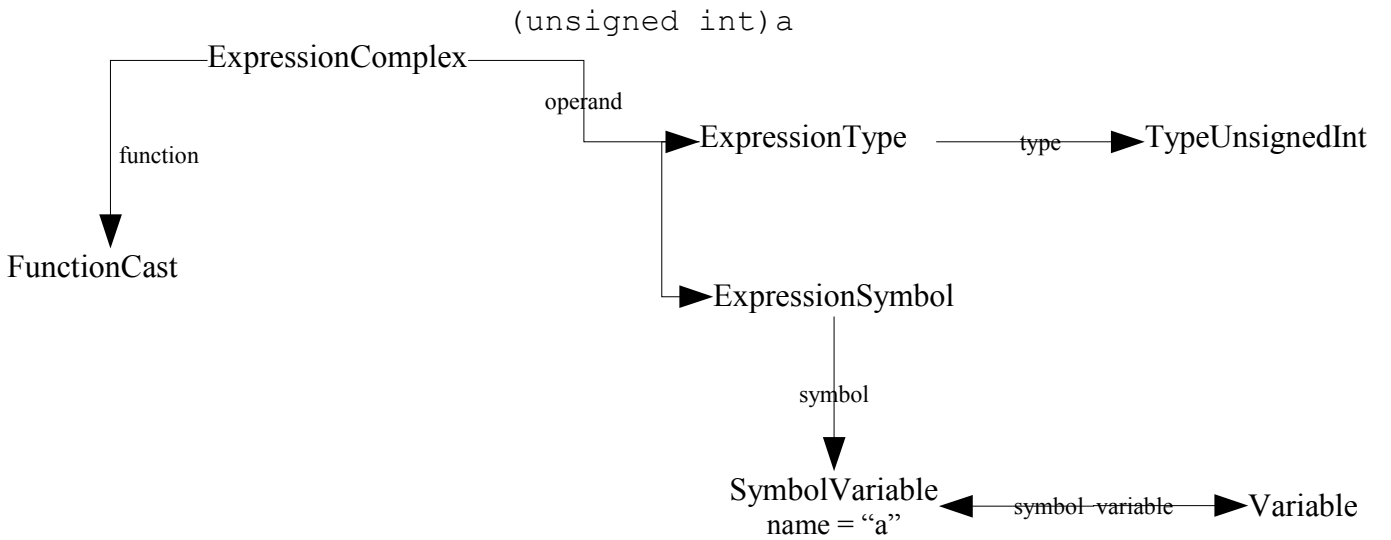
All other operators follow the same model:



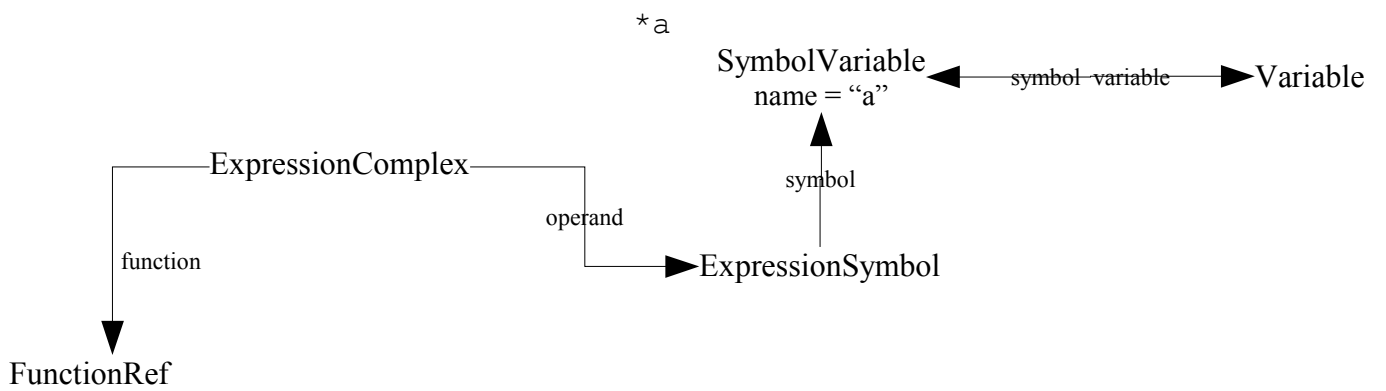
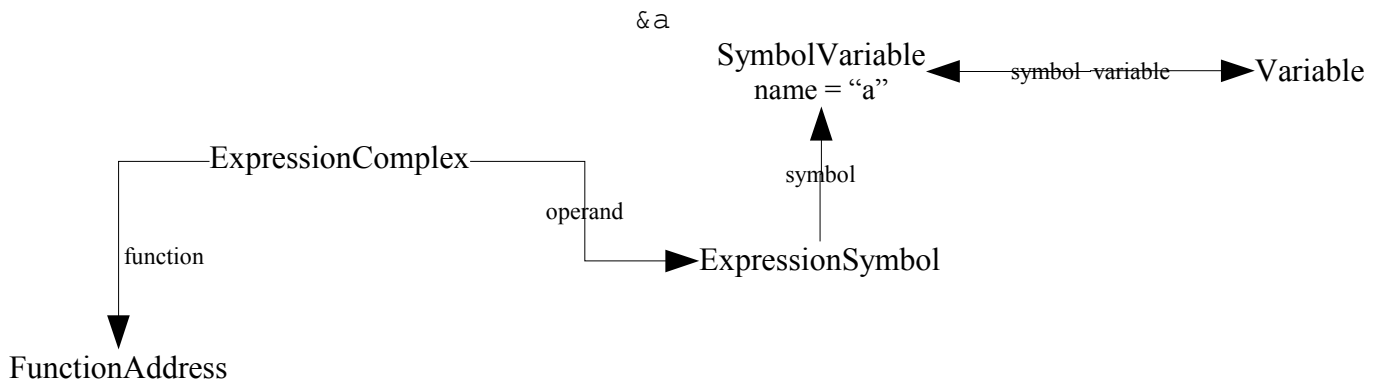
(note that 'a' has type int in C).

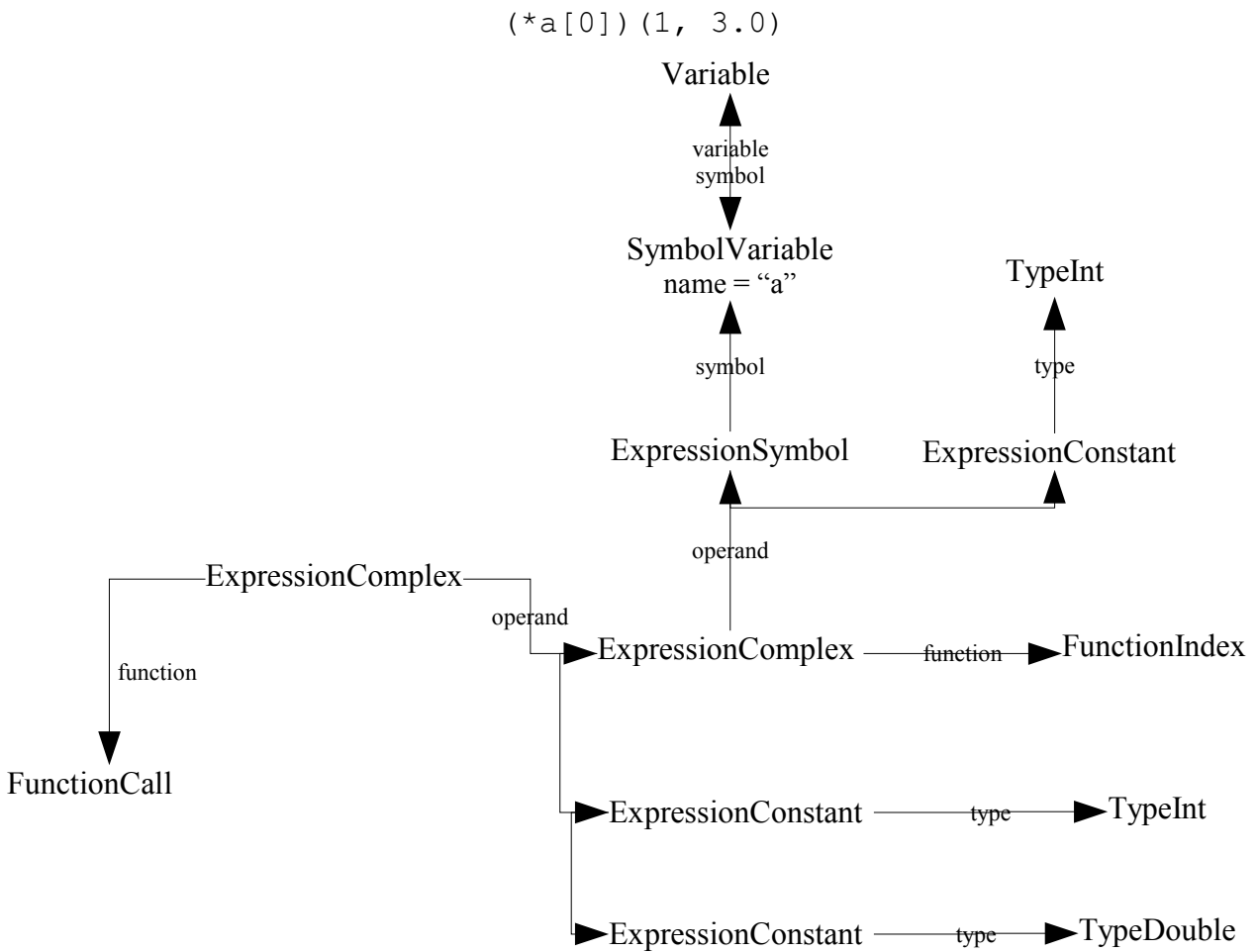
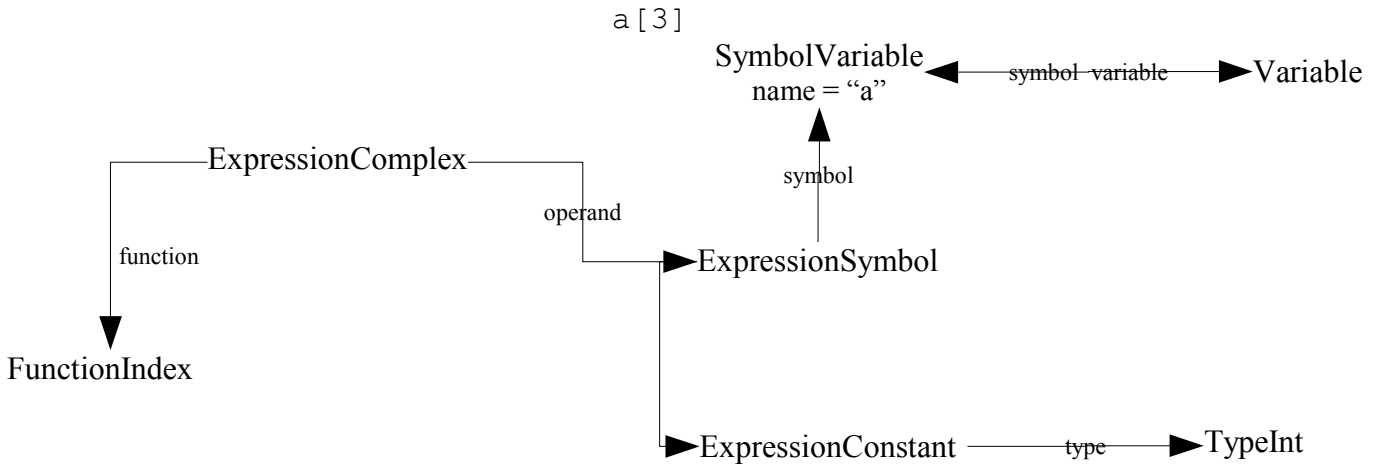
f(), g() (this is the comma operator, not the argument separator)



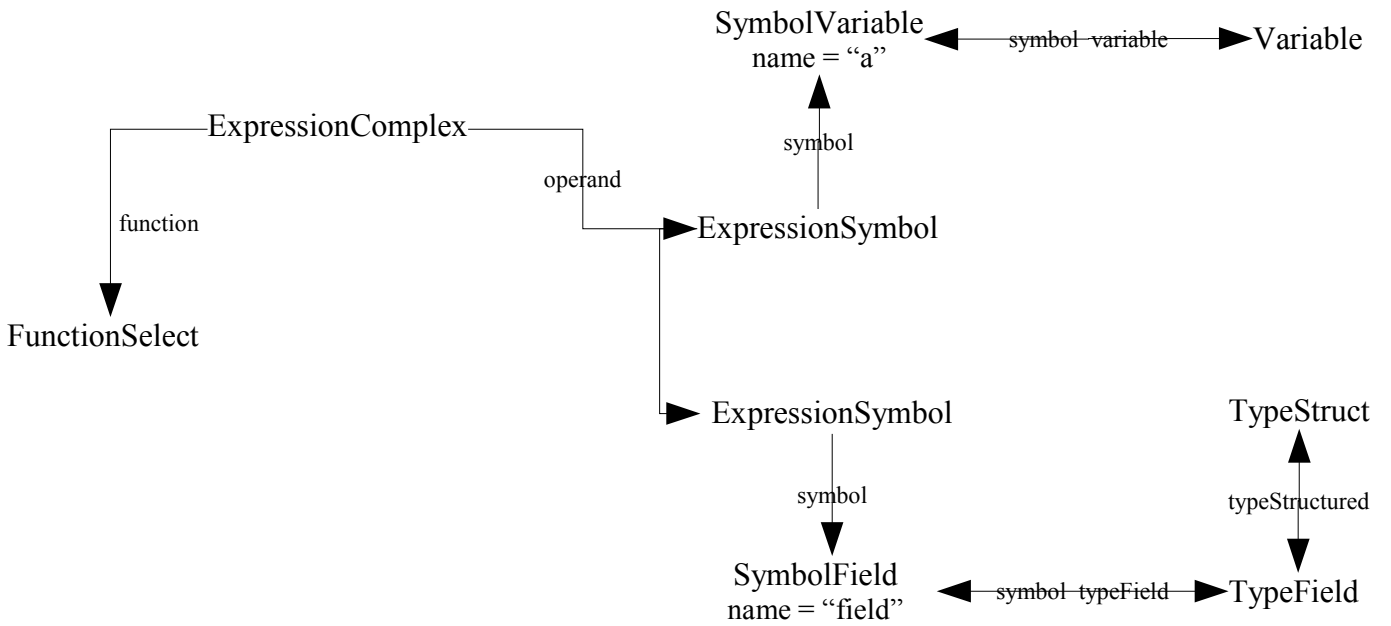


(note that ExpressionType is merely an adapter that allows to use a type as an expression.)

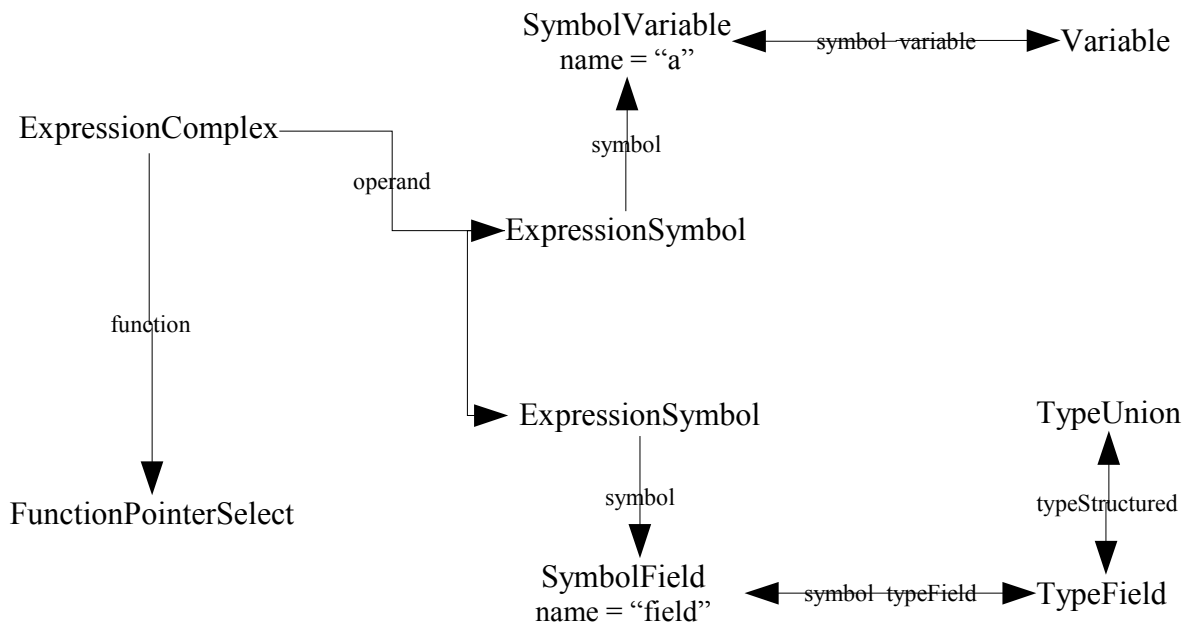




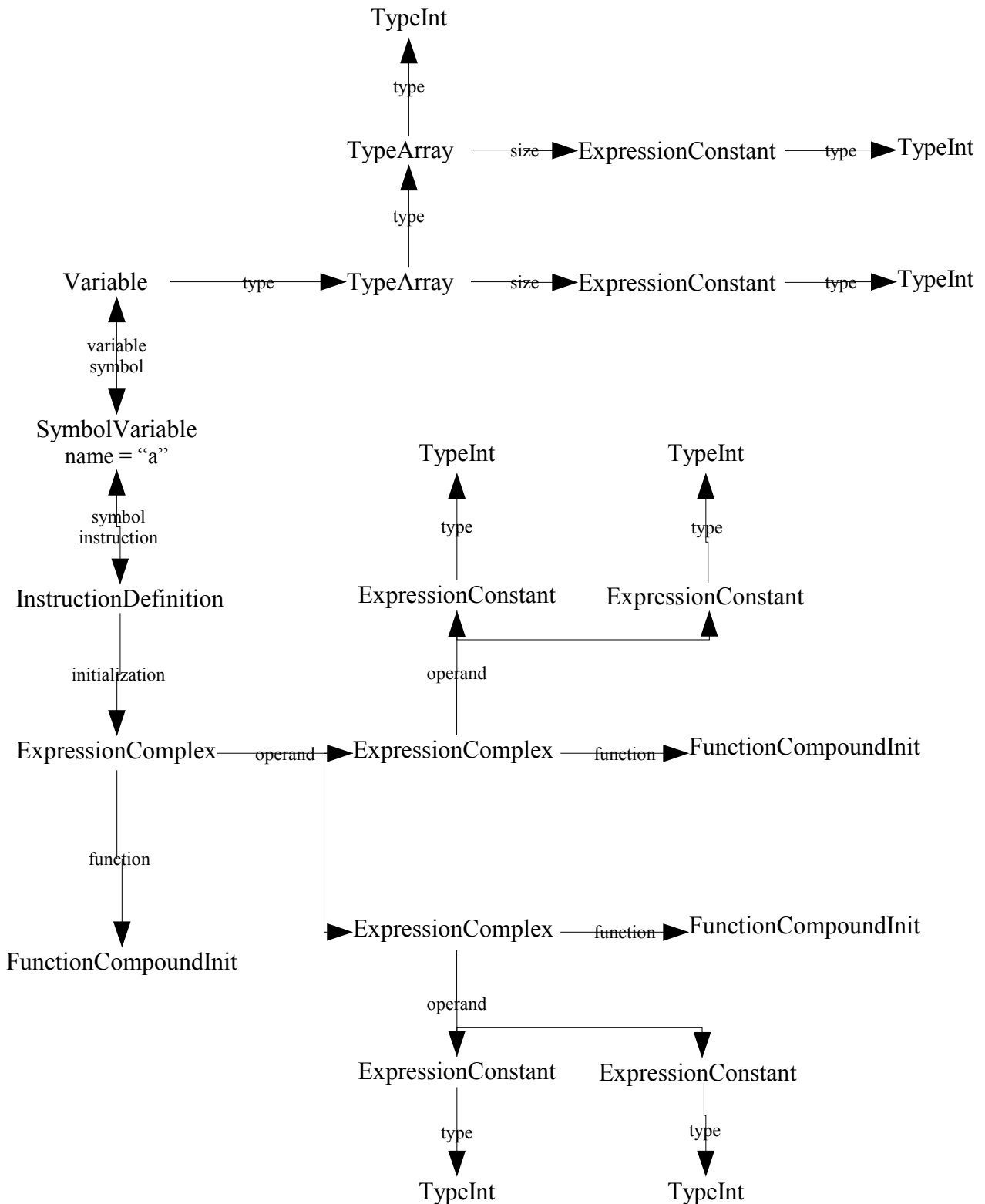
a.field



a->field



```
int a[2][2] = {{1, 2}, {3, 4}};
```

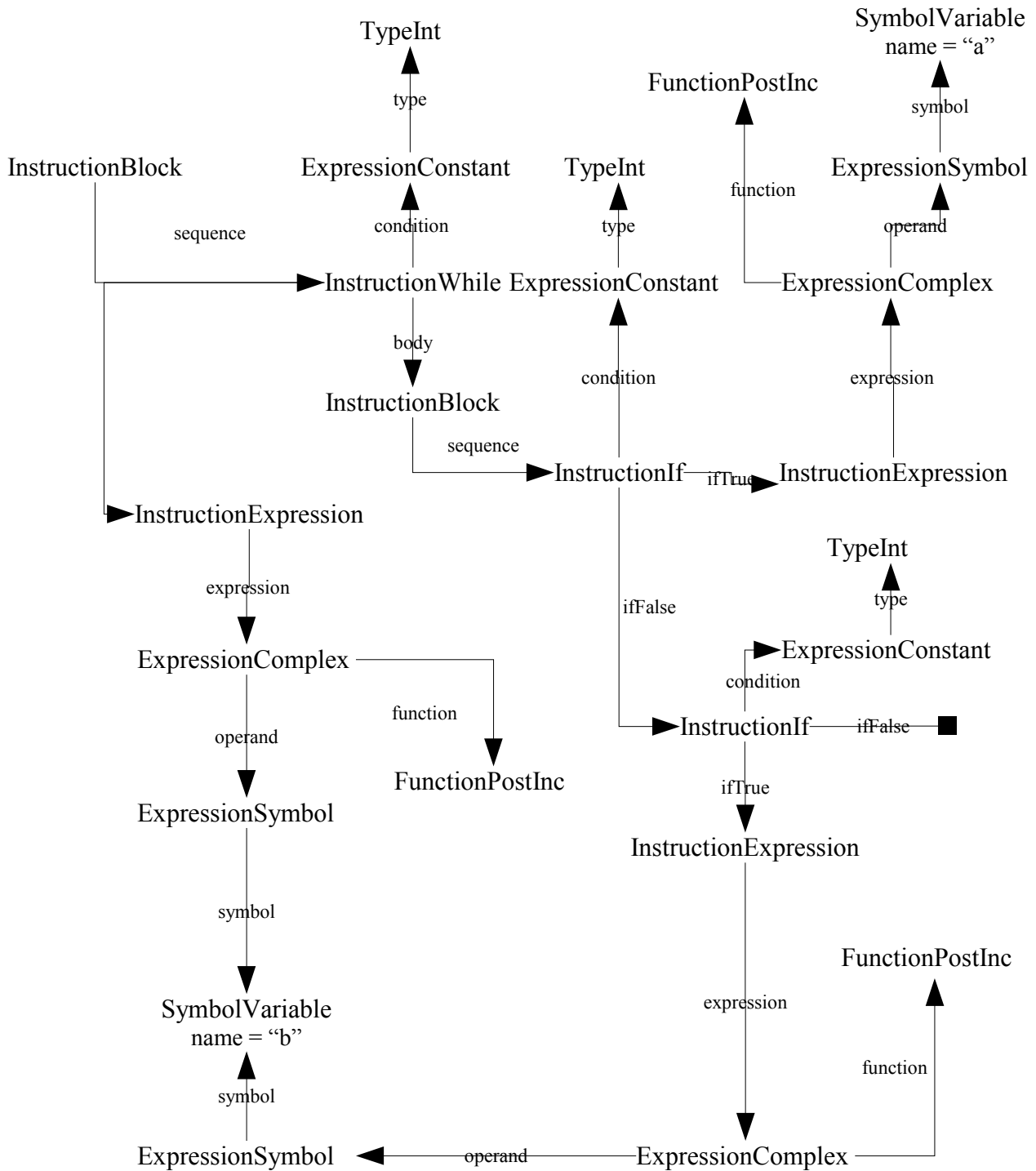


2.6. Instructions and Labels

The data model for instructions is rather straightforward, once `InstructionDeclaration`, `InstructionDefinition`, and `InstructionTentativeDefinition` are explained. The only remaining difficulty is with labels and `switch`.

But let's look first at a simple illustration of the data model for instructions:

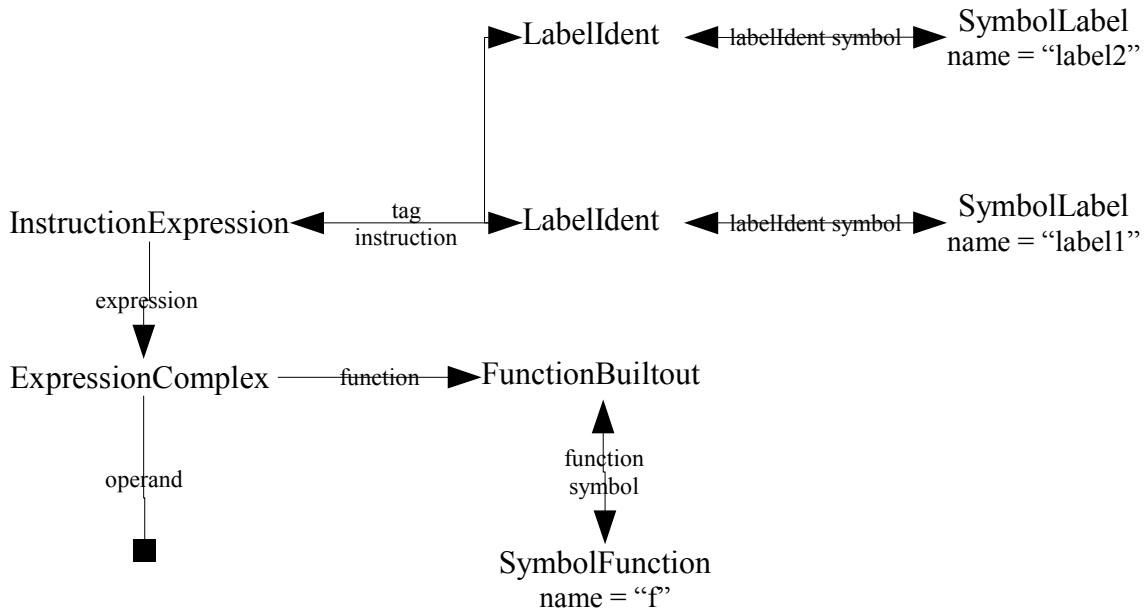
```
{
    while (1) {
        if (0)
            a++;
        else if (1)
            b++;
    }
    b++;
}
```



Instructions may be labeled, in order to allow the code to jump to a specific instruction with a goto (InstructionGoto) or a switch (InstructionSwitch). Thus the labels come in two flavors:

- Labels that may be used only in the body of a switch instruction: LabelCase and LabelDefault.
- Labels that may appear anywhere in the code: LabelIdent.

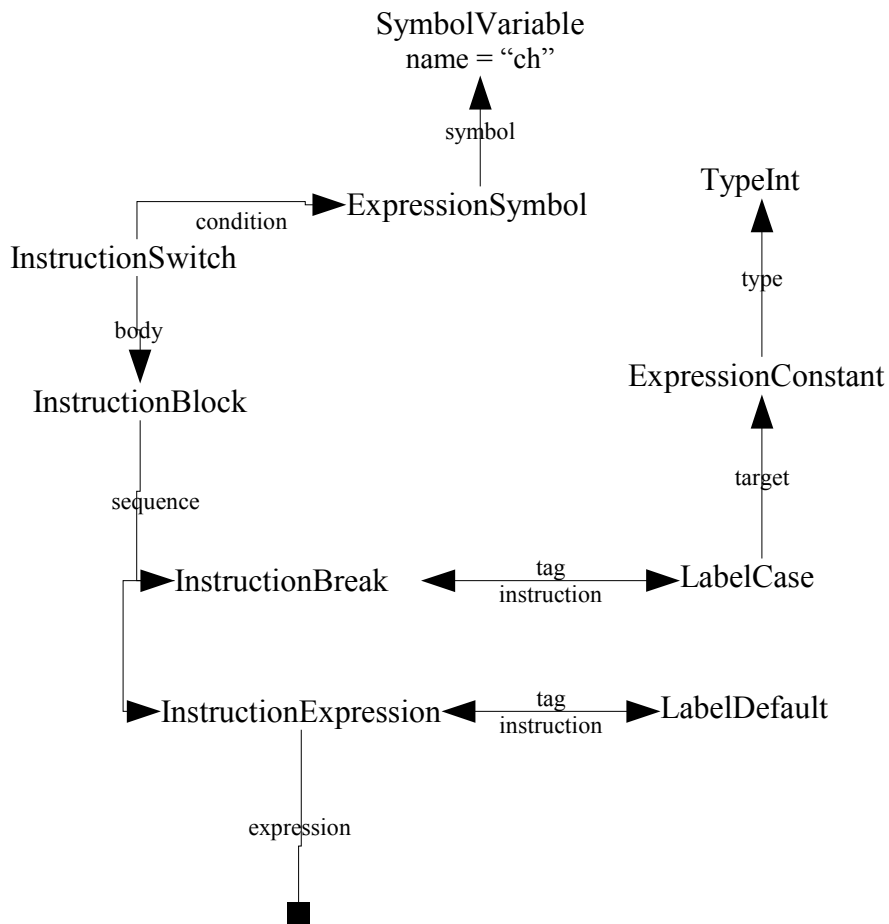
```
label1:
label2:
    f ( ) ;
```



```

switch (ch) {
case 'a':
    break;
default: ;
}

```



3. Shortcuts

The **TCL verifier** defines several shortcuts to ease common tasks:

The `application` object, root of the data model, has roles to most kinds of objects of the data model. Beware, however, that following these links may be costly for large applications, since there may be numerous objects in these roles.

The `Instruction*` objects have a role, `subInstruction`, that allows direct navigation to the `Instruction*` objects that are directly dependent on them.

The `Instruction*` objects have a role, `allInstruction`, that allows direct navigation to all `Instruction*` objects that are dependent on them.

The `Instruction*` objects have a role, `expression`, that allows direct navigation to the `Expression*` objects that are directly dependent on them, for example in the role `condition`.

The `Expression*` objects have a role, `subExpression`, that allows direct navigation to the `Expression*` objects that are directly dependent on them. For an `ExpressionComplex` object, this is equivalent to the role `operand`.

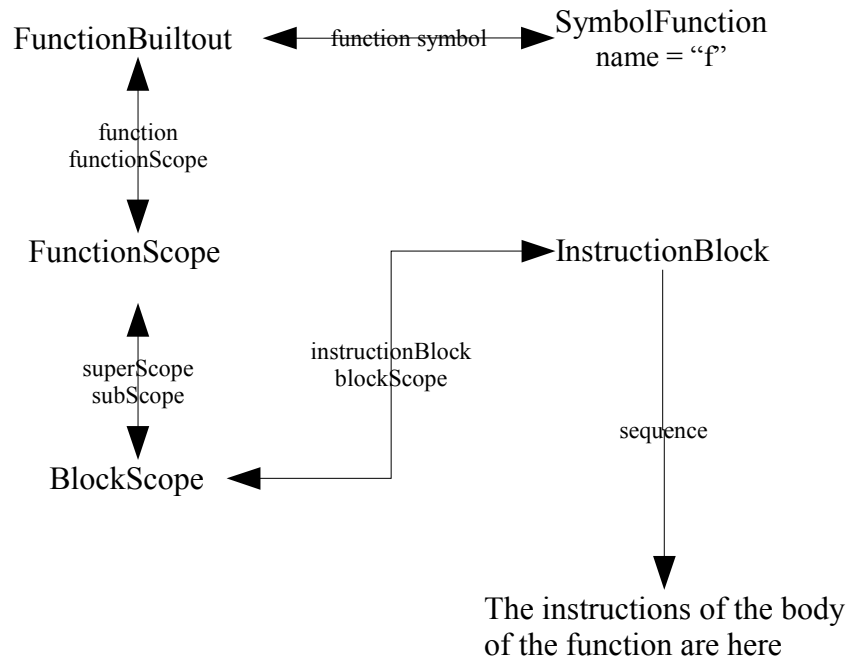
The `Expression*` objects have a role, `allExpression`, that allows direct navigation to all `Expression*` objects that are dependent on them.

The `allInstruction` and `allExpression` roles are very useful when searching for usage of identifiers in the code.

4. Special Cases

4.1. Finding the Function Body

It is often useful to find the body of a function, starting from a `FunctionBuiltin` object or a `SymbolFunction` object. The following schema describes how to retrieve it.



4.2. Implicit Function Declaration

The C language allows to call a function that is not declared. In such a case, the function is considered to be declared as returning `int` and with an unknown parameter list in the most enclosing scope.

The **TCL verifier** mimics this behavior by creating an `InstructionDeclaration` for a `SymbolFunction` for every undeclared identifier (function name or not). In order to reduce the cluttering of the data model for very old code that relies heavily on implicit function declaration, the `InstructionDeclaration` is created in the `ScopeGlobal`. These are the only `InstructionDeclaration` that may be found in the `instructionDef` role of the `ScopeGlobal`.

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