

The Whiley Language Specification

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January 2, 2014

Contents

1	Introduction	3
1.1	Overview	3
1.2	Goals	3
1.3	History	3
2	Lexical Structure	4
2.1	Indentation	4
2.2	Blocks	4
2.3	Whitespace	4
2.4	Identifiers	4
3	Compilation Units	5
3.1	Type Declarations	5
3.2	Constant Declarations	5
3.3	Function & Method Declarations	5
3.4	Visibility Modifiers	5
3.5	Packages	5
3.6	Imports	5
4	Types	6
4.1	Overview	6
4.2	Primitives	6
4.2.1	Any Type	7
4.2.2	Void Type	7
4.2.3	Null Type	7
4.2.4	Bool Type	7
4.2.5	Byte Type	8
4.2.6	Char Type	8
4.2.7	Int Type	8
4.2.8	Real Type	9
4.3	Tuple Types	9
4.4	Record Types	9
4.5	Reference Types	10
4.6	Nominal Types	10
4.7	Collection Types	10
4.7.1	Set Type	10
4.7.2	Map Type	11
4.7.3	List Type	11
4.8	Function Types	11
4.9	Method Types	11
4.10	Union Types	12
4.11	Intersection Types	12

4.12	Negation Types	12
4.13	Abstract Types	13
4.13.1	Recursive Types	13
4.13.2	Effective Tuples	13
4.13.3	Effective Records	13
4.13.4	Effective Collections	13
4.14	Subtyping Algorithms	13
5	Expressions	14
5.1	Binary Expressions	14
6	Statements	16
6.1	Variable Declarations	16
6.2	Assign Statements	16
6.3	Return Statements	16
6.4	If/Else Statements	16
6.5	While Statements	16
6.6	Do/While Statements	16
6.7	For Statements	16
6.8	Switch Statements	16
6.9	Try/Catch Statements	16

Chapter 1

Introduction

1.1 Overview

1.2 Goals

1.3 History

Chapter 2

Lexical Structure

2.1 Indentation

2.2 Blocks

2.3 Whitespace

2.4 Identifiers

Chapter 3

Compilation Units

3.1 Type Declarations

3.2 Constant Declarations

3.3 Function & Method Declarations

3.4 Visibility Modifiers

3.5 Packages

3.6 Imports

Chapter 4

Types

4.1 Overview

Discuss syntactic versus semantic types. Also, need to consider constrained types as well as type patterns.

```
Type ::=
      | TermType
      | UnionType
      | IntersectionType
```

```
TermType ::=
      | PrimitiveType
      | TupleType
      | RecordType
      | ReferenceType
      | NominalType
      | CollectionType
      | NegationType
      | FunctionType
      | MethodType
```

4.2 Primitives

```
PrimitiveType ::=
      | AnyType
      | VoidType
      | NullType
      | BoolType
      | ByteType
      | CharType
      | IntType
      | RealType
```

4.2.1 Any Type

```
AnyType ::= any
```

Description. The type **any** represents the type whose variables may hold any possible value.

Examples.

Semantics.

Notes. The **any** type is top in the type lattice. That is, it is the supertype of all other types.

4.2.2 Void Type

```
VoidType ::= void
```

Description. The **void** type represents the type whose variables cannot exist! That is, they cannot hold any possible value. Void is used to represent the return type of a function which does not return anything. However, it is also used to represent the element type of an empty list or set.

Examples.

Semantics.

Notes. The void type is a subtype of everything; that is, it is bottom in the type lattice.

4.2.3 Null Type

```
NullType ::= null
```

Description. The null type is a special type which should be used to show the absence of something. It is distinct from void, since variables can hold the special **null** value (whereas there is no special "void" value).

Examples.

Semantics.

Notes. With all of the problems surrounding **null** and `NullPointerException`s in languages like Java and C, it may seem that this type should be avoided. However, it remains a very useful abstraction to have around and, in Whiley, it is treated in a completely safe manner (unlike e.g. Java).

4.2.4 Bool Type


```
BoolType ::= bool
```

Description. Represents the set of boolean values (i.e. `true` and `false`).

Examples.

Semantics.

Notes.

4.2.5 Byte Type

```
ByteType ::= byte
```

Description. Represents a sequence of 8 bits.

Examples.

Semantics.

Notes. Unlike for many languages, there is no representation associated with a byte. For example, to extract an integer value from a byte, it must be explicitly decoded according to some representation (e.g. two's compliment) using an auxiliary function (e.g. `Byte.toInt()`).

4.2.6 Char Type

```
CharType ::= char
```

Description. Represents a unicode character.

Examples.

Semantics.

Notes.

4.2.7 Int Type

```
IntType ::= int
```

Description. Represents the set of (unbound) integer values.

Examples.

Semantics.

Notes. Since integer types in Whiley are unbounded, there is no equivalent to Java's `MIN_VALUE` and `MAX_VALUE` for `int` types.

4.2.8 Real Type

```
RealType ::= real
```

Description. Represents the set of (unbound) rational numbers.

Examples.

Semantics.

Notes.

4.3 Tuple Types

```
TupleType ::= ( Type ( , Type )+ )
```

Description. A tuple type describes a compound type made up of two or more subcomponents. It is similar to a record, except that fields are effectively anonymous.

Examples.

Semantics.

Notes.

4.4 Record Types

```
RecordType ::= { Type Ident ( , Type Ident )* [ , ... ] }
```

Description. A record is made up of a number of fields, each of which has a unique name. Each field has a corresponding type. One can think of a record as a special kind of "fixed" map (i.e. where we know exactly which entries we have).

Examples.

Semantics.

Notes. Syntax for functions? Open versus closed records?

4.5 Reference Types

```
ReferenceType ::= & Type
```

Description. Represents a reference to an object in Whiley.

Examples.

Semantics.

Notes.

4.6 Nominal Types

```
NominalType ::= Ident
```

Description. The existential type represents the an unknown type, defined at a given position.

Examples.

Semantics.

Notes.

4.7 Collection Types

4.7.1 Set Type

```
SetType ::= { Type }
```

Description. A set type describes set values whose elements are subtypes of the element type. For example, $\{1, 2, 3\}$ is an instance of set type `{int}`; however, $\{1.345\}$ is not.

Examples.

Semantics.

Notes.

4.7.2 Map Type

```
MapType ::= { Type => Type }
```

Description. A map represents a one-many mapping from variables of one type to variables of another type. For example, the map type `{int=>real}` represents a map from integers to real values. A valid instance of this type might be `{1=>1.2, 2=>3.0}`.

Examples.

Semantics.

Notes.

4.7.3 List Type

```
ListType ::= [ Type ]
```

Description. A list type describes list values whose elements are subtypes of the element type. For example, `[1, 2, 3]` is an instance of list type `[int]`; however, `[1.345]` is not.

Examples.

Semantics.

Notes.

4.8 Function Types

```
FunctionType ::= function ( [ Type ( , Type ) * ] ) => Type
```

Description.

Examples.

Semantics.

Notes.

4.9 Method Types

```
MethodType ::= method ( [ Type ( , Type ) * ] ) => Type
```

Description.

Examples.

Semantics.

Notes.

4.10 Union Types

$$\text{UnionType} ::= \text{IntersectionType} (\boxed{|} \text{IntersectionType})^+$$

Description. A union type represents a type whose variables may hold values from any of its "bounds". For example, the union type `null|int` indicates a variable can either hold an integer value, or `null`.

Examples.

Semantics.

Notes. There must be at least two bounds for a union type to make sense.

4.11 Intersection Types

$$\text{IntersectionType} ::= \text{TermType} (\boxed{\&} \text{TermType})^+$$

Description.

Examples.

Semantics.

Notes.

4.12 Negation Types

$$\text{NegationType} ::= \boxed{!} \text{Type}$$

Description. A negation type represents a type which accepts values *not* in a given type.

Examples.

Semantics.

Notes.

4.13 Abstract Types

4.13.1 Recursive Types

4.13.2 Effective Tuples

4.13.3 Effective Records

4.13.4 Effective Collections

4.14 Subtyping Algorithms

Discussion of soundness and completeness.

Expr	::=	Cond [(&&) Expr]	// Expressions
Cond	::=	Append [Cop Expr]	// Condition Expressions
Append	::=	Range [++ Expr]	// Append Expressions
Range	::=	AddSub [.. Expr]	// Range Expressions
AddSub	::=	MulDiv [(+ -) Expr]	// Additive Expressions
MulDiv	::=	Index [(* / %) Expr]	// Multiplicative Expressions
Index	::=	???	// Index Expressions

Figure 5.1: Syntax for Binary Expressions

Chapter 5

Expressions

5.1 Binary Expressions

Term	::=	<i>// Terms</i>	
	<i>Constant</i>		<i>// Constant expressions</i>
	<i>Identifier</i>		<i>// Identifier expressions</i>
	$Expr_1 (, Expr_i)^+$		<i>// Tuple expressions</i>
	$(Expr)$		<i>// Bracketed expressions</i>
	$ Expr $		<i>// Size expressions</i>
	$Identifier ([Expr_1 (, Expr_i)^+])$		<i>// Invocation expressions</i>
	$([- ! \sim \& *] Expr)$		<i>// Unary expressions</i>
	$new Expr$		<i>// Allocation expressions</i>
	$\{ [Expr_1 (, Expr_i)^*] \}$		<i>// Set expressions</i>
	$\{ [Expr_1 \Rightarrow Expr'_1 (, Expr_i \Rightarrow Expr'_i)^*] \}$		<i>// Map expressions</i>
	$[[Expr_1 (, Expr_i)^*]]$		<i>// List expressions</i>
	$\{ [n_1 : Expr_1 (, n_i : Expr_i)^*] \}$		<i>// Record expressions</i>

Figure 5.2: Syntax for Term Expressions

Constant	::=	<i>// Constants</i>	
	$([0 1])^+ b$		<i>// Boolean constants</i>
	$([0-9])^+$		<i>// Integer constants</i>
	$([0-9])^+ . ([0-9])^+$		<i>// Decimal constants</i>
	$null$		<i>// Null constant</i>

Figure 5.3: Syntax for Constant Expressions

Identifier	::=	$([- a-z A-Z] ([- a-z A-Z 0-9])^*)$	<i>// Identifiers</i>
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Figure 5.4: Syntax for Identifiers

Chapter 6

Statements

6.1 Variable Declarations

6.2 Assign Statements

6.3 Return Statements

6.4 If/Else Statements

6.5 While Statements

6.6 Do/While Statements

6.7 For Statements

6.8 Switch Statements

6.9 Try/Catch Statements