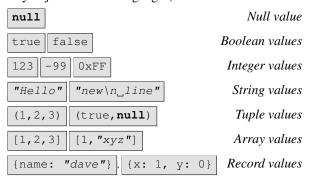
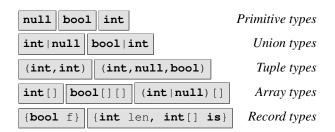
Values

Values are the fundamental units of execution in Whiley and have value semantics, rather than reference semantics (as in many object-oriented languages).



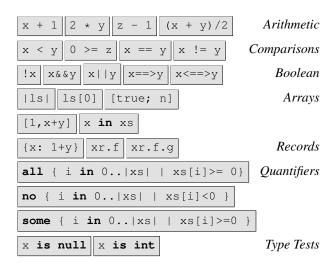
Types

The Whiley programming language is *statically typed*, meaning that every expression has a type determined at compile time. Furthermore, evaluating an expression is guaranteed to yield a value of its type.



Expressions

The majority of work performed by a Whiley program is through the execution of *expressions*. Every expression produces a value and may have additional side effects.



By David J. Pearce, 2014. See http://whiley.org

Statements

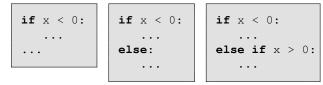
The execution of a Whiley program is controlled by *statements*, which cause effects on the environment. Statements in Whiley do not produce values. Compound statements may contain other statements.

Variables are declared and initialised through *variable declarations*. Variables must be declared before being used.

Variables, fields and map or list elements can be *assigned*. Variables must be defined before being used.

$$x = x + y$$
 $x[0] = 1$ $r.f = 3$ $x,y = t$

Conditional statements control the flow of execution based on the result of a boolean expression.



Looping statements control the flow of execution by repeating some sequence of statements zero or more times.

```
while x<0:
    ...
    while x<0
    ...
    while x<0
    ...
</pre>
```

Switch statements control execution flow by matching the result of an expression.

```
switch x:
    case 1:
        x = x + 1
    case 1,2:
        x = 0
```

```
switch x:
    case 1:
        x = x + 1
    default:
        x = 0
```

Return statements terminate the execution of a function or method and may return the result of an expression.

```
return x + 3 return x, y
```

Assertion and assumption statements enable the programmer to express knowledge at a given point.

Break statements terminate loops early; *debug* statements enable output from functions; *skip* statements are a no-op.

break debug "got_here" skip

Declarations

A *declaration* declares a named entity within a source file and may refer to named entities in this or other source files and (in some cases) may *recursively* refer to itself.

Constant declarations define constants with known values at compile-time (they cannot be recursively defined).

```
constant TEN is 10
constant TWENTY is TEN * 2
```

Type declarations define named types composed from other types (they may be recursively defined).

```
type Point is { int x, int y }

type Link is { LinkedList next, int data }
type LinkedList is null | Link
```

Function declarations define functions which are pure and may not have side-effects. They are guaranteed to return the same result given the same arguments, and are permitted within specifications.

```
function find(int[] xs, int x) -> int:
...
```

Method declarations define methods which are *impure* and may have side-effects. They cannot be used within specifications.

```
method main(System.Console console):
    console.out.println("Hello_World")
```

Specifications

A *precondition* is a condition over the parameters of a function that must hold when the function is called. A *post-condition* is a condition over the return values of a function which is required to be true after the function is called.

```
function decrement(int x) -> (int y)
// Parameter x must be greater than zero
requires x > 0
// Return must be greater or equal to zero
ensures y >= 0
// Return must be less than input
ensures y < x:
//
return x - 1</pre>
```

A *data-type invariant* is a constraint on the values of a declared type which must be true for any instance of it.

```
type nat is (int n) where n >= 0
type pos is (int p) where p > 0
```

A *loop invariant* is a property which holds before and after each iteration of the loop, such that: (1) the loop invariant must hold on entry to the loop; (2) assuming the loop invariant holds at the start of the loop body (along with the condition), it must hold at the end; (3) the loop invariant (along with the negated condition) can be assumed to hold immediately after the loop.

```
...
int i = 0
while i < x where i >= 0:
    i = i + 1
...
```

Examples

The following function computes the maximum value of two integer parameters.

```
function max(int x, int y) -> (int z)
// must return either x or y
ensures x == z || y == z
// return must be as large as x and y
ensures x <= z && y <= z:
// implementation
if x > y:
    return x
else:
    return y
```

The following function uses a **break** to exit a **while** loop when the first element matching parameter x is found.

```
// Find index of matching element, or return -1
function indexOf(int[] xs, int x) -> int:
  int i = 0
//
while i < |xs| where i >= 0:
  if xs[i] == x:
    return i
  i = i + 1
return -1
```

The following function computes the length of a linked list.

```
//A linked list is either the empty list or a link
type LinkedList is null | Link
//A single link in a linked list
type Link is {int data, LinkedList next}

//Return length of linked list (i.e. number of links it contains)
function length (LinkedList 1) -> int:
    if 1 is null:
        // l now has type null
        return 0
else:
        // l now has type {int data, LinkedList next}
        return 1 + length(l.next)
```

The following function reverses the values in a list of integers.

```
function reverse(int[] xs) -> (int[] ys)
// size of lists are the same
ensures |xs| == |ys|:
   int i = 0
   int[] zs = xs
//
   while i<|xs| where i>=0 && |xs|==|zs|:
      int j = |xs| - (i+1)
      xs[i] = zs[j]
      i = i + 1
   return xs
```