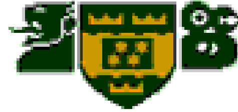

The Whiley Programming Language

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http://whiley.org

Java:

```
void buildLabelMap(List<Bytecode> bytecodes) {
  HashMap<String,Integer> labels = new HashMap<String,Integer>();
  int idx = 0
  for(Bytecode b : bytecodes) {
    if(b instanceof Bytecode.Label) {
      Bytecode.Label lab = (Bytecode.Label) b;
      labels.put(lab.name, idx);
    }
    idx = idx + 1;
} }
```

Python:

```
def buildLabelMap(bytecodes):
  labels = {}
  idx = 0
  for b in bytecodes:
    if type(b) == "Label":
        labels[b.name] = idx
    idx = idx + 1
```

The Whiley Language

```
void buildLabelMap([Bytecode] bytecodes):
  labels = {->}
  idx = 0
  for b in bytecodes:
    if b is Label:
      labels[b.name] = idx
    idx = idx + 1
```

- Design Goals:
  - **Look and feel** of a dynamically typed language
  - But, still provide **static** type checking
  - **Simple** programming model
  - Amenable to **program verification**

Data Types

- **Unbound** Integers and Rationals
  - `int` currently implemented BigInteger
  - `real` currently implemented as BigRational
  - How to do this efficiently on JVM?

- Lists, Sets and Maps:

```
int sum([int] list):
   r = 0
   for x in list:
       r = r + x
   return r
```

- Records:

```
define Point as {int x, int y}
```

Constraints

```
int sum([int] list) requires no {x in $ | x < 0},
                    ensures $ >= 0:
   r = 0
   for x in list:
       r = r + x
   return r
```

```
define nat as int where $ >= 0
define natlist as [nat]

nat sum(natlist list):
   …
   return r
```

- Pre/Post Conditions and Invariants:
  - **Goal** is to check at compile time
  - **Currently**, checked at run time

Flow-Sensitive Typing

```
Value evaluate(Expr e, {string->Value} env) throws Error:
    if e is int:
        return e
    else if e is Var:
        return env[e.id]
    else if e is BinOp:
        lhs = evaluate(e.lhs, env)
        rhs = evaluate(e.rhs, env)
        …
```

- Flow-Sensitive Typing:
  - Variables declared by **assignment**
  - Variables automatically **retyped** by type tests
  - Variables can have **different types** at different points

Union Types

```
null|int indexOf(string str, char c):
   …

[string] split(string str, char c):
    idx = indexOf(str,c)
    if idx is int:
        below = str[0..idx]
        above = str[idx..]
        return [below,above]
    else:
        return [str]
```

- Union types have many uses
  - Such as neatly handling null references
  - Or, combining different kinds (i.e. `union`s of `struct`s)

Structural Subtyping

```
define LinkedList as null | {int dat, LinkedList nxt}

int sum(LinkedList l):
  if l == null:
    return 0
  else:
    return l.dat + sum(l.nxt)

void main(System sys, [string] args):
  l={dat: 1, nxt: null}
  l={dat: 2, nxt: l}
  sys.out.println(sum(l))
```

- Defined types are **not nominal**
  - i.e. LinkedList is just a name that "expands"

Structural Subtyping

```
define LinkedList as null | {int dat, LinkedList nxt}

int sum(LinkedList l):
  if l == null:
    return 0
  else:
    return l.dat + sum(l.nxt)

void main(System sys, [string] args):
  l={dat: 1,nxt: null} // l is {int dat, null nxt}
  l={dat: 2,nxt: l} // l is {int dat, {int dat, null nxt} nxt}}
  sys.out.println(sum(l))
```

- Defined types are **not nominal**
  - i.e. LinkedList is just a name that "expands"

Value Semantics

```
Board applyMove(Move move, Board board) throws Move.Invalid:
    nboard = applyMoveDispatch(move,board)
    if !validMove(move,board,nboard):
        throw Move.Invalid(board,move)
    else:
        return nboard
```

- Whiley does not have references!
  - **Everything** is pass-by-value
  - Data propagates only via return
  - Much more **functional** in nature
  - Requires different way of **thinking**

Reference Counting

```
Board applySimple(Board b, Pos old, Pos pos, Piece piece):
   b[old.col][old.row] = null
   b[pos.col][pos.row] = piece
   return board

Board applyMove(Board b, Move m):
   if move is Simple:
       …
       return update(b, m.from, m.to, m.piece)
```

- Value semantics:
  - Copy board for call to applySimple()
  - Copy again for assignments in applySimple()
  - But, this is very inefficient!!!

  - Reference counting can really help here…

Digression

- Item 24, Effective Java
  - Make Defensive Copies when Needed

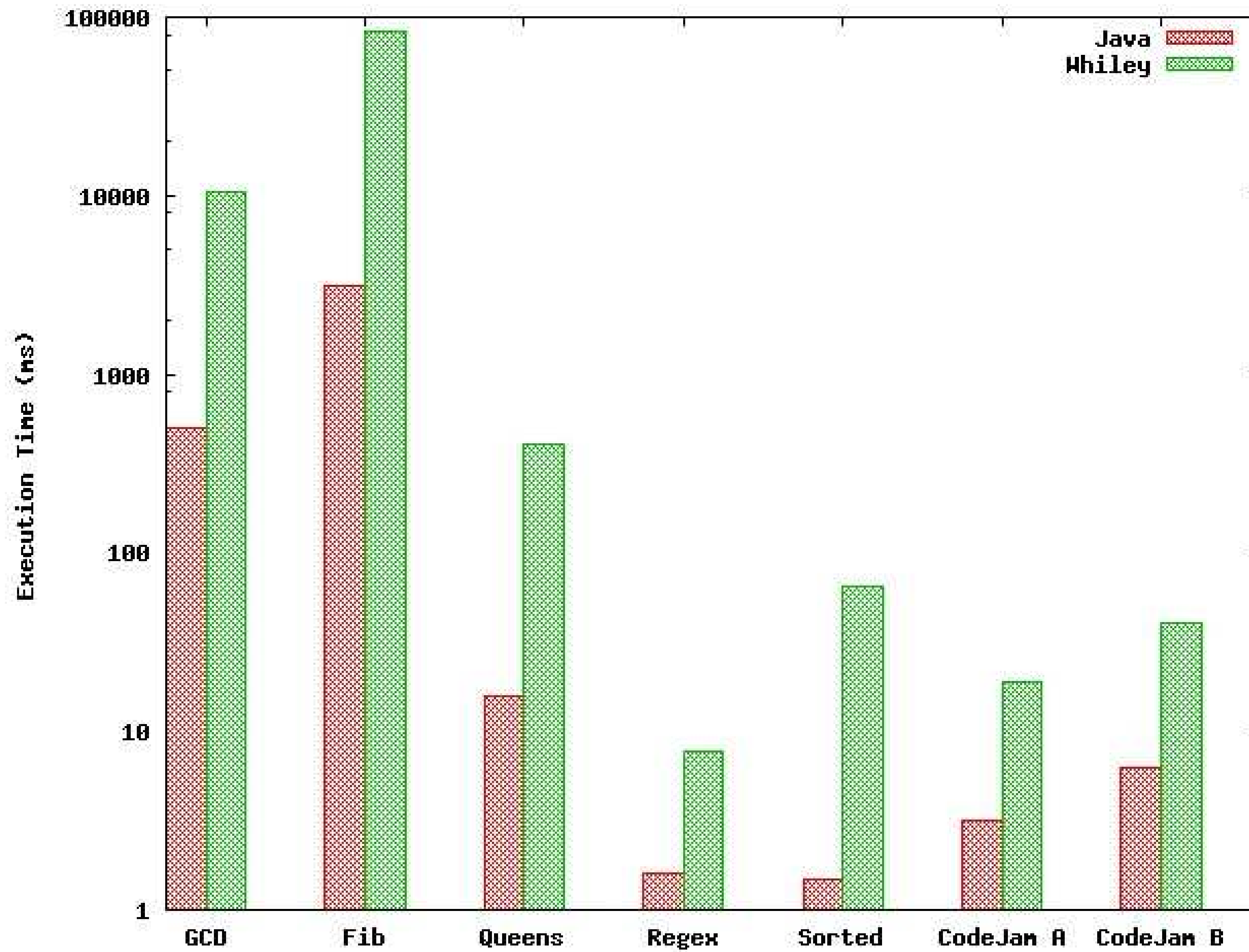
"It is essential to make a defensive copy of each mutable parameter to the constructor"

-- Josh Bloch

Effectiveness of Ref Counting

Benchmark	LOC	# Clones	% Clones
Gunzip	815	873 / 140561	0.62%
JASM	2333	12878 / 29968	43.0%
Chess	784	6438 / 416116	1.6%
Calc	225	0 / 81527	0.0%
SCC	169	12602 / 258968	4.86%

Performance



Java Interoperation

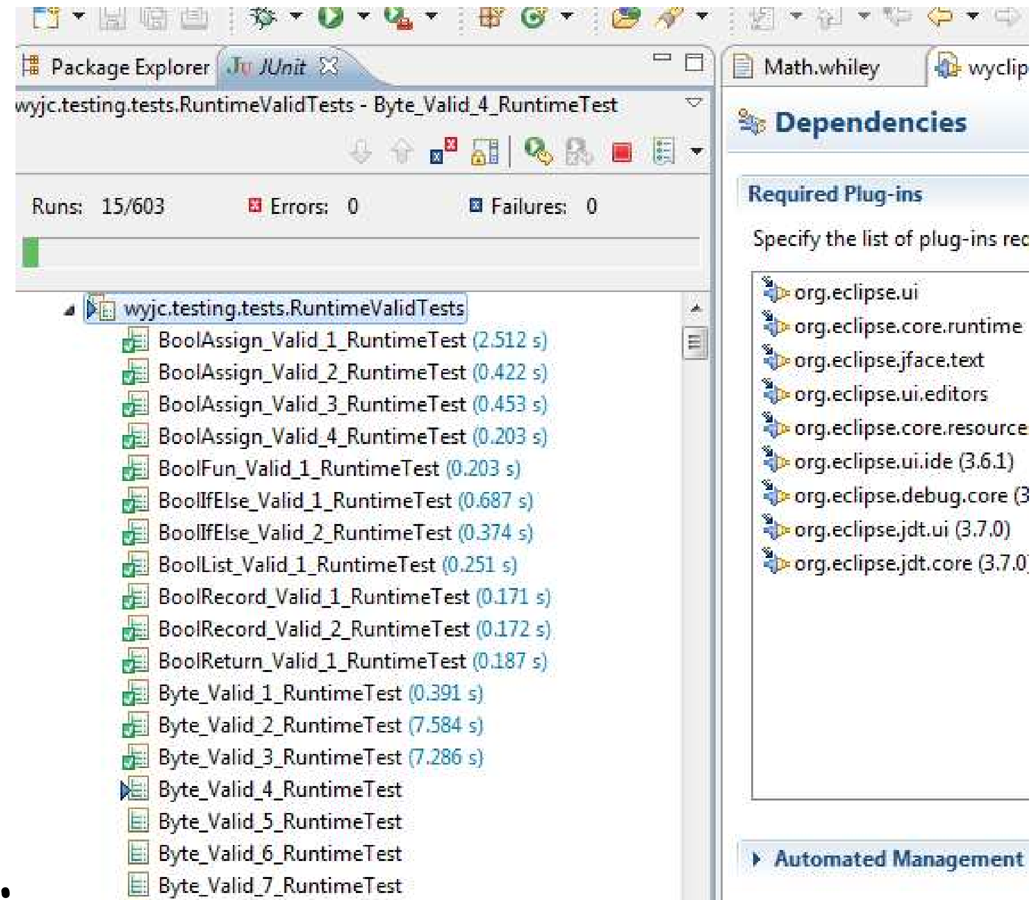
Sum.whiley:

```
…

public native int sum([int] list):

…
```

Sum$native.java:

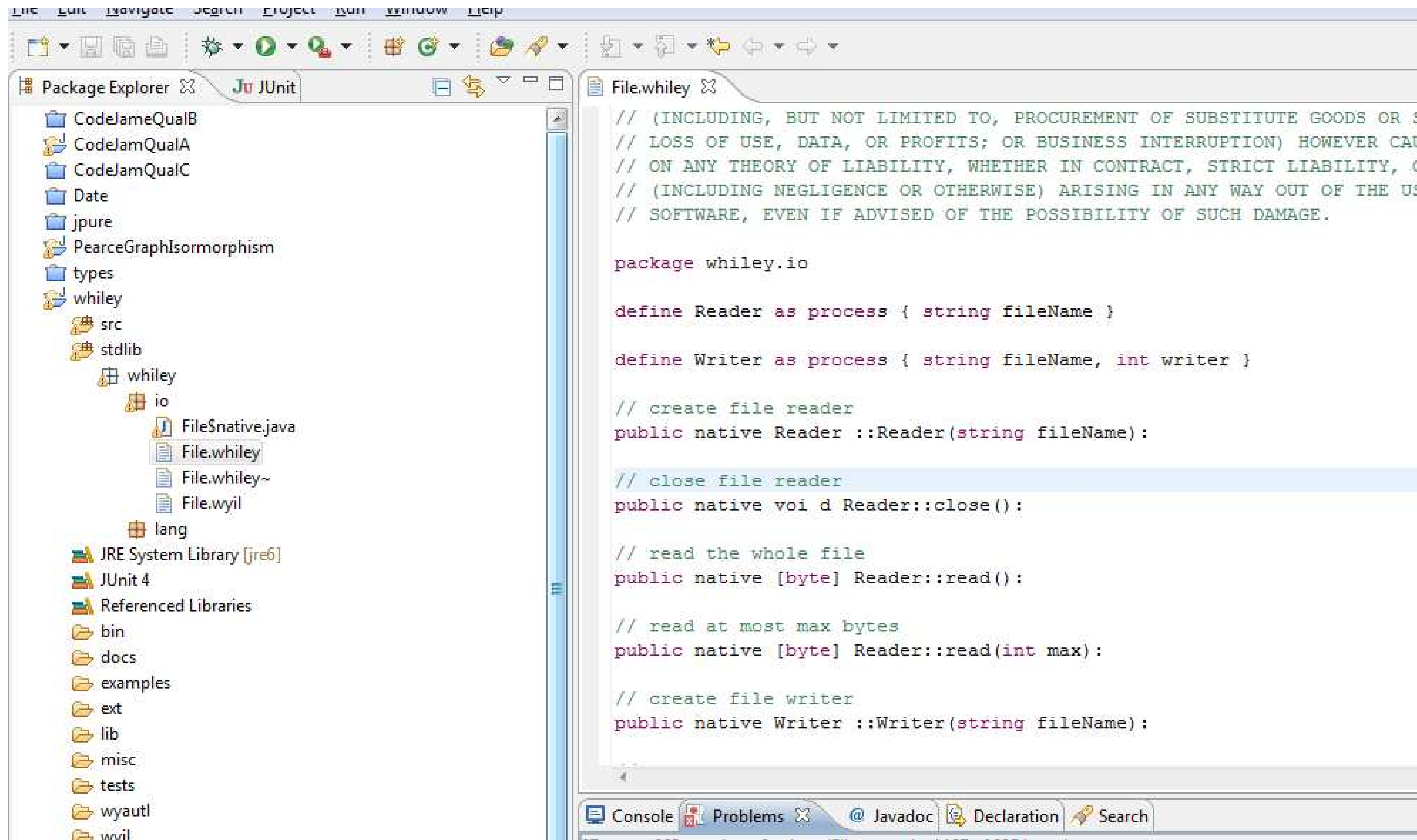
```
…

public BigInteger sum(wyjc.runtime.List list) {
    …
}

…
```

Testing



- Testing:
  - Some 600 end-end tests
  - Over 15,000 unit tests of type system!

Eclipse Plugin



- **Update Site:** http://whiley.org/eclipse

http://whiley.org