INTRODUCING NJEXL
A DECLARATIVE JVM LANGUAGE FOR AUTOMATED VALIDATION

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ABSTRACT. nJexl is a derivative of Apache Jexl project [1]. The motivation for nJexl are domain specific languages (DSL) like VERILOG [2], VHDL [3]. DSL for Software testing is not a new idea, many commercial tools like Silk Suite [5] use them, while Selenese, the DSL for Selenium IDE [6] is open source. nJexl is a functionally motivated, embeddable, Turing Complete [7] language. It’s philosophy is to expose the existing Java echo system in a declarative fashion for the purpose of software validation [9]. By design nJexl script size is meagre compared to Python or even Scala for validation problems. Author’s firm heavily uses nJexl for software automation purpose which drastically reduced the effort for automatic verification for a year now.

1. INTRODUCING nJEXL

1.1. Introductory Remarks. Tenet of today is: Churn code out, faster, and with less issues and make end users happy. That is the precise idea behind of Test Driven Development (TDD)[9]. The economy of testing in a fast paced release cycle puts automatic validation into foray. Still, given there are not many people allocated for the testing efforts overall (some firms actually makes user do their testing) there is an upper cut-off on what can be accommodated, even through automation. Hence, the idea is Getting More Done, with Less. nJexl sprang out of this idea, a scripting language based on Java Virtual Machine (JVM), embeddable in any other JVM language, concise to write, and declarative by design, so that mathematical logic [11] can be written with almost no modification using nJexl.

1.2. nJexl at a Glance. The syntax of nJexl is heavily influenced by Python[12] and Scala[13]. nJexl is given keywords which are pretty standard across popular languages [14]:

1) Control Flow: if, else, where, for, while, break, continue, return.
2) Logical: and, or, xor, gt, ge, lt, le, eq, not.
3) Definitions: def, var, import, as.
4) Literals: 'string', "string", true, false, null.
5) Object Creation: new.

Basic data structures are array, list, set, dict, heap. nJexl is loosely typed, such that types are inferred automatically. Elementary data types are chrono: date, time, instant; byte, short, int, long, float, double, INT, DEC, range. There are utility functions by default which takes care of type conversions, comparisons, and comprehensions on collections. Most
of the assignment operations automatically uses appropriate container type for a variable. Global variables are defined using `var`.

```plaintext
x = int('42', 0) // cast 42 into int, if failed, return 0
d = date('19470815','yyyyMMdd') // string to a date using format
a = [1,2,3] // a is an integer array
d = { 0 : false , 1 : true } // d is a dictionary
s = set(1,2,2,2,3) // s is a set of (1,2,3)
// f is automatically converted into BigDecimal, no loss of precision
f = 0.10010001718181888188981313873444111
// fp is a variable, containing a nameless function adding its two params
fp = def(a,b){ a + b }
```

There are higher order functions available, and every function is capable of taking a function as input. Nesting of functions exists, and strings can be evaluated as nJexl scripts.

Interaction with underlying system and network is possible via i/o operations like `read`, `write`, `print`, `send` and creating a process and a thread is possible via `system`, `thread` functions.

1.3. Introducing Control Flow : FizzBuzz. To showcase control flow, FizzBuzz is a good example. The problem statement is: Given a number is divisible by 3 print Fizz, if divisible by 5 print Buzz, and if neither print the number. The solution is as follows:

```plaintext
def fizz_buzz(upto){ // defining a method with a known named parameter
  // create dictionary
  fb_hash = { 0 : 'FizzBuzz' , 3 : 'Fizz', 5 : 'Buzz',
             6 : 'Fizz', 9 : 'Fizz', 10 : 'Buzz', 12 : 'Fizz' }
  for ( i : [1:upto+1]){ // iterate over a range
    r = i % 15 // modulo operator
    // if r in the hash, then, else... classic ternary
    print ( r @ fb_hash ? fb_hash[r] : i )
  }
}
```

1.4. Anonymous Function as Parameter in Higher Order Functions. To demonstrate the feature of using higher order functions, we solve the problem of finding the largest line from a file.

```plaintext
def largest_line(file_name){
  line_range = lines(file_name) // gets a lazy range (iterator) of lines
  // comparator : size of left < size of right implies left < right
  #(min,MAX) = minmax{ size($0) < size($1) }( line_range )
  // multiple assignment sets min to min, and MAX to MAX length string
  print (MAX)
}
```

SQL like syntax is available in the form of `join` which is the most general form of collection interwinding. The following code generates all permutations of a string `word`:

```plaintext
n = #|word| // get cardinal size of a collection
l = [0:n].list() // get a list out of a range
ll = list( l ){0:n}) // get a list of list
```
1.5. Reading URL, Clocking, List Comprehensions, Sorting. Suppose we do want to test how fast certain portion of code runs. nJexl comes with a default construct to solve it. Here, in the below code we benchmark the load time of google.co.in:

```nJexl
def benchmark(url, count){
    def get_time(url){ // nested function
        #(t,o) = #clock { read(url) } // clock the read nanoseconds
        return t
    }
    timings = list{ get_time(url) }([0:count]) // comprehension
    timings = sortd(timings) // sorting descending
    i = int ( 0.1 * count ) // find 90%
    timings[i] // return is optional keyword
}()

t = benchmark( ’http://www.google.co.in’, 30 )
print(t)
```

1.6. Import, Error Handling. The underlying system is capable of raising errors, so while nJexl does not support try...catch...finally constructs, it is capable of raising and catching errors.

```nJexl
import ’java.lang.Integer’ as Int // import Integer class as alias Int
// :x signifies the error to be caught , call static parseInt
#(o,e) = Int:parseInt(’The answer to everything is 42’)
print(o) // is null
print(e) // NumberFormatException
```

2. nJexl in Practice

In this section we introduce three problems of increasing difficulty, discuss where the problem really lies, and explain formulation of such a problem using mathematical logic, and then we solve them declaratively using nJexl [15].

2.1. Validation of Sorting. There is a function $S$ which takes a list of objects $l_i$ (say integers) and returns a sorted list $l_o$, how to test that the $S$ did the job correctly [9]? The problem is two faced, not only it requires to verify that the $l_o$ is ordered, but also that $l_o$ is a permutation of $l_i$. Suppose $I = \{1,2,...,|l_o|−1\}$. Formally, the validation now becomes:

$$l_o = l_i \text{ and } \not\exists i \in I \text{ such that } l_o[i−1] > l_o[i]$$

Here is how to solve it using nJexl:
def is_sorted_permutation(l_i, l_o):
    return (l_i == l_o and # "==" tests permutation [1,2] == [2,1]
    # _ defines the current item index, $ is the current item, $$ the list
    # index function returns the index (-1 for failure) of occurrence of condition
    # which was specified in the braces known as anonymous function block -->{ }
    index( _ > 0 and $$[_-1] > $ |(l_o) < 0 )
)

2.2. Filtering. There is a function $F$ which takes a list of objects $l$, and a predicate $P$, and generates a list: $F(l, P) = l_F$. Clearly $l_F \subseteq l$ such that $l_F = \{ x \in l | P(x) = True \}$.
How to verify that the function $F(P,l)$ worked correctly? Here is the code in nJexl that solves it :

def verify_applied_filter(P, l, l_F):
    # find the failure location
    failure_index = index( { not P($) } |(l_F)
    # sublist check is as easy as <=
    return failure_index < 0 and ( l_F <= l )

2.3. Comparing Tabular Results. Given two list of tuples $L, R$ (perhaps results of two different versions of the same reporting software) verify if they are indeed same list or not. The problem exists because the any tuple $t_l \in L$ can match to any tuple $t_r \in R$. The ordering of components in the tuples $t_l, t_r$ might differ. Hence, there is a precise ordering imposed by the ordering index sets $I_l, I_r$, such that for index $i$ component $t_l[I_l[i]]$ must be compared with component $t_r[I_r[i]]$. The nJexl solution is as follows:

// _$_ is the partial result of the fold function
def verify_tables(l, r, I_l, I_r):
    # list of strings from tuples 'l' each has components ordered by I_l
    ll = list{
        t = $ ; lfold( _$_ += (t[$] + ') |(I_l,'') ) |(l)
    # list of strings from tuples 'r' each has components ordered by I_r
    lr = list{
        t = $ ; lfold( _$_ += (t[$] + ') |(I_r,'') ) |(r)
    # now compare ...
    ll == lr
}

3. Summary & Resources

3.1. Summary. There was no language available which lets one intermingle with Java POJOs and lets one write test automation thinking validation first. As almost all of modern enterprise application are written using JVM stack, it is impossible to avoid JVM and write test automation, because in many cases one would need to call appropriate Java methods to automate APIs. Being imperative does not help, because who tests the test code itself? These examples presented showcase how declarative paradigm can be used to validate problems, all of which would have otherwise required many lines of coding.
imperatively. In the Authors firm, a project testing generic REST services of 3K lines of Java code was reduced to 10 lines of nJexl.

This is the idea behind nJexl: a declarative and functionally inclined open sourced language that incorporates all the good stuffs from the vast Java libraries, while not being verbose enough to let testers focus on validation strategies, not on writing imperative code to solve a problem which can easily be solved declaratively. nJexl itself is an example of TDD in practice, having 83% instruction coverage by unit tests. Authors firm heavily uses nJexl for validation problems of any nature, and thus able to reduce the automation effort (both new and maintenance) to 5% of the pre nJexl era. Empirically, the learning curve for nJexl for a Java aware person is found to be a month.

3.2. Online Resources. The following are the online resources:

1. Download Location for binary for this Document
   https://github.com/nmondal/njexl/releases/tag/Alpha-2-preview
2. Installation Instructions
   https://github.com/nmondal/njexl/wiki/0-An-Easy-Tutorial#environment-setup
3. Source Code
   https://github.com/nmondal/njexl
4. Wiki Pages
   https://github.com/nmondal/njexl/wiki
5. Manual
   https://github.com/nmondal/njexl/raw/master/doc/pdfs/nJexl.pdf

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