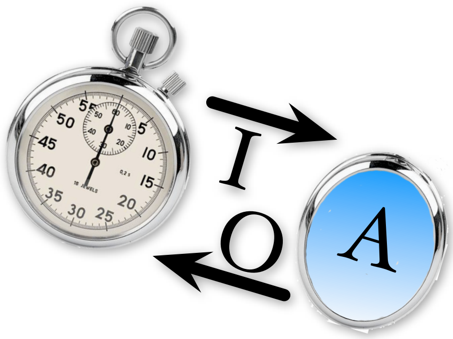
TIOA RELEASE NOTES

v0.1.0 (BETA)

8/31/2006



Language changes

Typing

The new implementation considers that Bool is a subtype of Nat. The type hierarchy for numbers is thus as follows

```
    Bool <: Nat <: Int <: Real <: AugmentedReal
```

Associativity and Precedence

The new implementation supports traditional associativity for all binary operators. In particular, an expression like

```
x + y < z * w
```

now yields the “natural” parse tree

```
((x + y) < (z * w))
```

Rather than

```
((((x) + y) < z) * w)
```

The precedence and associativity follow traditional programming languages and are summarized below:

Operator	Description	Associativity

`()`
`[]`
`.`
	Parentheses (grouping)
	Brackets (array subscript and tupling)
	Member selection via object name
		left

`+ -`
`~`
`type:ex`
	Unary plus/minus
	Unary logical negation
	Type selection
		right

`* / %`	Binary Multiplication/division/modulus	left
`+ -`	Binary Addition/subtraction	left

`< <=`
`> >=`
	Relational less than/less than or equal to
	Relational greater than/greater than or equal to
		left

`= ~=`	Relational is equal to/is not equal to	left
`**`	Exponentiation	right
`/\`	Logical and	left
`\/`	Logical or	left
`=> <=>`	Logical implication and equivalence	left
`\A \E`	Universal and Existential quantifiers	left

Invariant Scoping

Invariant scopes are not limited to the automaton they reference. For example, the TIOA model below

```
automaton A
 signature output out
  states x: Bool
 transitions output out

automaton B
 signature output out
  states x: Bool
 transitions output out

invariant of A:
 A.x;
 B.x
```

used to report an error on the last line because B was unknown. The current implementation finds B's definition in the "parent" (global) scope and type checks the model correctly.

Choose statement

Choose statements require that the chosen variable's type exactly equals the type of the left hand value. For instance, in the TIOA model

```
automaton A
  signature output act
  states chosen: Int
  transitions
    output act
      eff
        chosen := choose x where 1 <= x /\ x <= 30;      <-- x must be an Int
        chosen := choose x:Real where 1 <= x /\ x <= 30; <-- x cannot be a Real
```

The new checker rejects the last choose statement because the modeler forced x to be of type Real which is a super type of chosen's type.

Differential equations in trajectories

1. Overloading: The new checker does not allow the identifier 'd' to be used. It is reserved for the derivative function. The old checker only prohibited overloading of 'd' as a Real -> Real function

2. Type Spec: The new checker extends the type spec of 'd' from Real -> Real to AugmentedReal -> AugmentedReal. A number of examples from the Simulator used this construction.

IF-THEN-ELSE expression

This syntactic form is now obsoleted in favor of the more traditional lower case variant if-then-else

Implicit Type Declarations

In the new checker no types are generated implicitly. All types must appear in a type definition construction beginning with the key word "types", ether in a vocabulary or in a global type declaration. For instance, the declaration

```
Automaton A(type M) ....

Automaton B
   components   A(Square)
   ...
```

will no longer introduce a type 'Square' implicitly. Instead, the modeler is requested to explicitly declare which names denote types. To this end, the type definition construction is now authorized at the top level. The example above could be rewritten as

```
types Square;
Automaton A(type M) ....

Automaton B
    components A(Square)
    ...
```

Type Selectors

Type selection used to be important to manually assist the front-end in resolving type ambiguities when several objects of the same name but with different types coexist. The old front-end used to attempt a type selection based on the typing context and the known objects. The new front-end implement stricter scoping rules (resulting in fewer instances of ambiguous constructions) and is equipped with a more flexible type inference mechanism capable to resolve type ambiguities more often. As a result, manual type selection is becoming less and less useful and we strongly encourage modelers to refrain from using it.

Variable overloading

Variables can no longer be overloaded by type. In each scope an Identifier can only refer to one object.

Null vocabulary

The __.val method of the Null vocabulary was changed to a unary function val(__). For example an expression

```
x.val = nil
```

now becomes

```
val(x)= nil
```

Top level declarations

1. As stated before, types declaration can now appear at the top-level
2. Vocabulary import statements can also appear at the top-level (e.g., to import types needed to instantiate automata)

Floating-point literals

It is now possible to enter floating-point literals directly (e.g. 2.5467)

Scoping Rules

The scoping mechanism of the new checker is much more extensive. Previously, variables existed in the same scope and could be overloaded by using different types, and then selected using a type selector. Now variables cannot be overloaded in the same scope, but they may be redefined or shadowed in a nested scope, with the same type or a different type. This forces each identifier to be unique in a given scope. Note that several constructions automatically create scopes, for instance

- Vocabularies: Scope for vocabulary body
- Automaton definition: Scope for the automaton formal and a nested scope for the automaton body
- Action: Scope for action formal and a nested scope for the action body
- Quantifiers: Scope for the nested expression

Plugins Notes

Each plugin imposes its own set of restrictions on the core TIOA language. Depending on which tool is selected, your model may or may not comply and the front-end will report additional errors that are tool dependent. The remainder of this document briefly reviews each tool and the restrictions imposed by that tool. Complete documentation on how to use each plugin can found in the documentation directory.

1. PVS

Parametric Types

Parametric types in vocabularies and automaton specifications are not supported. For example, the following are not supported:

```
vocabulary MyVoc defines MyType[T] ...

vocabulary myVoc(T: type) ...

automaton test(mytype:type) ...
```

A work-around is to declare a type construct within a vocabulary, and then use the “inc1” option to specify a PVS uninterpreted type in an include file. For example, one could write the following:

```
vocabulary myvocab
  types mytype
end
imports myvocab
automaton test
   signature output out
   states x:mytype, y:Seq[mytype], z:Null[mytype] ...
```

Then, one should use the “inc1” option to include a file containing an uninterpreted type in the PVS output. For example, an include file named “file.inc” contains:

```
mytype: TYPE
```

Then the configuration file should contain the option “inc1:file.inc” on a single line.

Built-in Types

All built-in types are supported except “String” and “Mset”. In addition, for the “Seq” type, the assignment operator is not supported. Thus, the following statement is not supported, where “s” is of type “Seq”:

```
s[i] := x
```

Identifiers

Reserved words in PVS should not be used as identifiers in the TIOA specification. In addition, the translator also uses a fixed list of names in the output of the translation, and these names should be avoided whenever possible to prevent unnecessary overloading in PVS. For example, names such as “actions”, “delta_t”, “time”, “theory”, “begin”, etc. should not be used.

Action and transition signatures

Formal parameters of an action or transition should not use the “const” keyword, and should not be literals. For example, the following is not allowed:

```
input send(const i, const j)
```

One could rewrite the above using a “where” clause into an acceptable form:

```
input send(i1:Int, j1:Int) where i=i1 /\ j=j1
```

As another example, the following is not allowed:

```
output out(0)
```

Again, it is possible rewrite using a “where” clause to obtain an acceptable form:

```
output out(i) where i=0
```

Action and transition constructs

The following constructs within actions and transitions are not allowed:

- choose
- ensuring
- hidden
- local

Trajectory evolve clause

Evolve clause of a trajectory should be either a constant differential equation or a constant differential inclusion. Higher orders not supported currently. For example, the following expressions are allowed:

```
   d(x) = k, d(x) >= k, d(x)<= k, d(x) > k, d(x) < k,
```

where "k" is a literal constant.

Simulation relations

Only forward simulations are allowed. Backward simulations are not supported.

When a simulation relation is defined from automaton A to automaton B, both A and B should have the same set of external actions.

Proof entries in a simulation relation are ignored.

Composition

Composite automata are not supported.

Schedules

Schedule blocks are ignored.

2. UPPAAL

Variable types

All the declared state variables could be only Int, Nat, Bool, Enum and the array of these four types except time variable. Time variable can be only Real, which means set, map, tuple, sequence, union etc. are all not allowed, imported vocabulary can only be Enum. Also, "const", "type" and "local" keywords are not allowed.

Disallowed syntactic constructions

1. Where clause are not allowed, no matter appears in where, e.g., automaton header, signature etc.
2. "let" clause is not allowed
3. "choose" clause and "initially" clause are not allowed
4. "urgent when" clause is not allowed

5. "ensuring" clause is not allowed
6. "hidden" actions are not allowed
7. Universal and existential quantifiers are not allowed (\A and \E)
8. Automaton state dereference is limited to components of composite automata
9. The "\infty" constant is not allowed
10. if-then, for loop statements are not allowed, effect statements are restricted to assignment and if-then statements only. If an if-then statement is used there may only be one and all other statements in the effects clause must be contained inside the body of the then clause.

Constructions that are discarded (The translator will simply discard the construction and carry on with the translation):

1. Task blocks are ignored.
2. Invariant statements are ignored.
3. Schedule block are ignored.
4. Simulation (forward simulation, backward simulation) blocks are ignored

Functions

Only the following functions are supported by the model checker,

```
div, mod, pred, succ, min, max
```

Signatures

Signature overloading is not allowed

Transitions

1. Internal transitions can't have parameters
2. Precondition clauses cannot contain disjunctions

Trajectories

Trajectory evolve clauses are limited to d(t)=1 (time evolves at constant rate 1). Trajectories have the format

```
invariant mode = ...
stop when time = ...
```

where "mode" variable is fixed to be one of the enum value of the Location type. The differential equation must have the form

```
d(t)=c
```

where c is a constant value typed as a real. The variable t in d(t) must be a real.

3. Simulator

The simulator imposes a certain number of restrictions on the core TIOA language. These restrictions are listed below and will be progressively removed as new releases come out.

Null Vocabulary

The simulator does not support the Null vocabulary. Any attempt to import this builtin vocabulary will result in a semantic error. This is a temporary restriction that will be lifted shortly.

State variables declarations

The declaration of a state variable must always include an initialization statement. For instance the fragment

```
automaton A
state
x : Int
```

will trigger an error whereas

```
automaton A
state
x : Int := 10;
```

is acceptable.

composition

Currently IR does not implement automata composition, hence only primitive automata are allowed in the specifications.

det statements

det statements are not implemented in the IR.

Simulation

Simulation is not implemented in the IR.

tasks

Tasks are not implemented in the IR.

Dereferencing

This is only a temporary restriction. The simulator only allows a single dereferencing level, as demonstrated in this example. However, even with this restriction one can still access deeper levels with use of the local variables.

Expressions and quantifiers

Quantifier expression that the simulator can resolve have to based on enumerable types, examples of things that are not enumerable are:

```
AugmentedReal, Char, DiscreteReal, Int, Real, Seq, MSet, Null, Set, String
```

This means that the we only support quantifiers on:

```
Bool, Nat, and user Enum vocabs
```

choose statements

Currently the choose statement may only appear in the state declarations. The choose statements on numerical built-in data types (i.e. Nat, Int, Real, DiscreteReal, AugmentedReal) and may be of the following form:

```
:= choose x where ____ (/\  or \/) ____
:= choose x where ____
```

where the ____ may be a simple of the form

```
x (~=, =, >, >=, <, <=) literal
```

or

```
literal (~=, =, >, >=, <, <=) x
```

Note that these are legal on all data types:

```
:= choose
:= choose x
```

Of course these are equivalent to simply not initializing the state variable at all.

Choose statements may not appear in other parts of the specification.

global types

Global types have to be encapsulated by

```
vocabulary
    ...
end
```

Otherwise the simulator will not recognize them.

let definitions

Unfortunately, let definitions are not allowed. The simulator cannot find implementations for these functions and hence does not know how to simulate them.

Schedules

Simulator must have a schedule block in order to simulate any specification. If no schedule block is given then the only output that will be given to the user is that of the internal representation of the specification that is passed in to the simulator. However, the simulator will demand a schedule block if two conditions are true:

1. specification has trajectories
2. specification has parametrized actions

For-statements

Simulator supports only these for-statements that have as a predicate a condition on a set, for example:

```
for j:Nat in s do
     ...
od;
```

where s is a Set[Nat]. Any other predicate is not supported.

Evolve statement

The simulator currently restricts the evolve statements to the following format:

```
d(x) = lit
```

where lit may be an integer or a decimal value. All other evolve statements are not supported, some examples of these are:

```
d(x) > 5;
d(x) = x;  --- where x is a variable
```

Multiple automata

Simulator currently supports only a single primitive automaton, this means no composition and no simulation.

Smart fire

Currently the simulator requires user to provide a schedule which includes fire statements that are followed by an action kind and name, with parameters if any are needed. Basically, it is not able to choose an enable action from the pool of all enabled action in a given state.

Transition terms

The parameters in the transition must be variables. Moreover, if a transition has more than one parameter, then the variables must have unique names. Note that the simulator will not complain when it is provided with a constant value, such as:

```
output out(10)
output out(true)
```

However, there are two issues, (1) providing a constant literal as a parameter does not make the transition unique and the first one will be called (as listed in the specification). (2) This is an example of a sloppy programming, since this parameter cannot be assigned to any variable inside the transition.

User defined operators in vocabulary

As it is the case with the let statements, these are not supported.

Automata formal parameters

These can only be of the following type:

1. Nat
2. Int
3. Real
4. DiscreteReal
5. AugmentedReal
6. Bool

Enjoy!