PRAGMAList

An integrated tool for **modeling and optimized test generation** driven by ✓ **coverage** and ✓ **properties**

Model-Based Testing: an Approach with SDL/RTDS and DIVERSITY

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PRAGMADEV
real time development tools

cea tech
List

PragmaDev

- French SME,
- Created in 2001 by 2 experts in modelling tools and languages.
- Dedicated to the development of a modelling and testing tool for the development of **Event driven software**.

Aero/Defence

AIRBUS, esa, DGA, CS COMMUNICATION & SYSTEMES

Automotive

RENAULT

Telecoms

Alcatel·Lucent, AEROFLEX, ERCOM, WIPRO, NewLogic, LG Electronics, THOMSON images & beyond, KETI Korea Electronics Technology Institute

Semi-conductor

ST ERICSSON, TOSHIBA, MITSUMI

700 active university licenses around the world

Several Collaborative Projects with big accounts

Alcatel·Lucent → ExotLicus

Focus on Model Checking

Started in 2005
finished in 2009

THALES → 

Focus on property verification

Started in 2012
finished in 2014

cea list → PRAGMAList

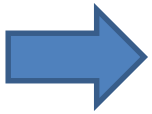
Focus on Model Based Testing

Started in 2013

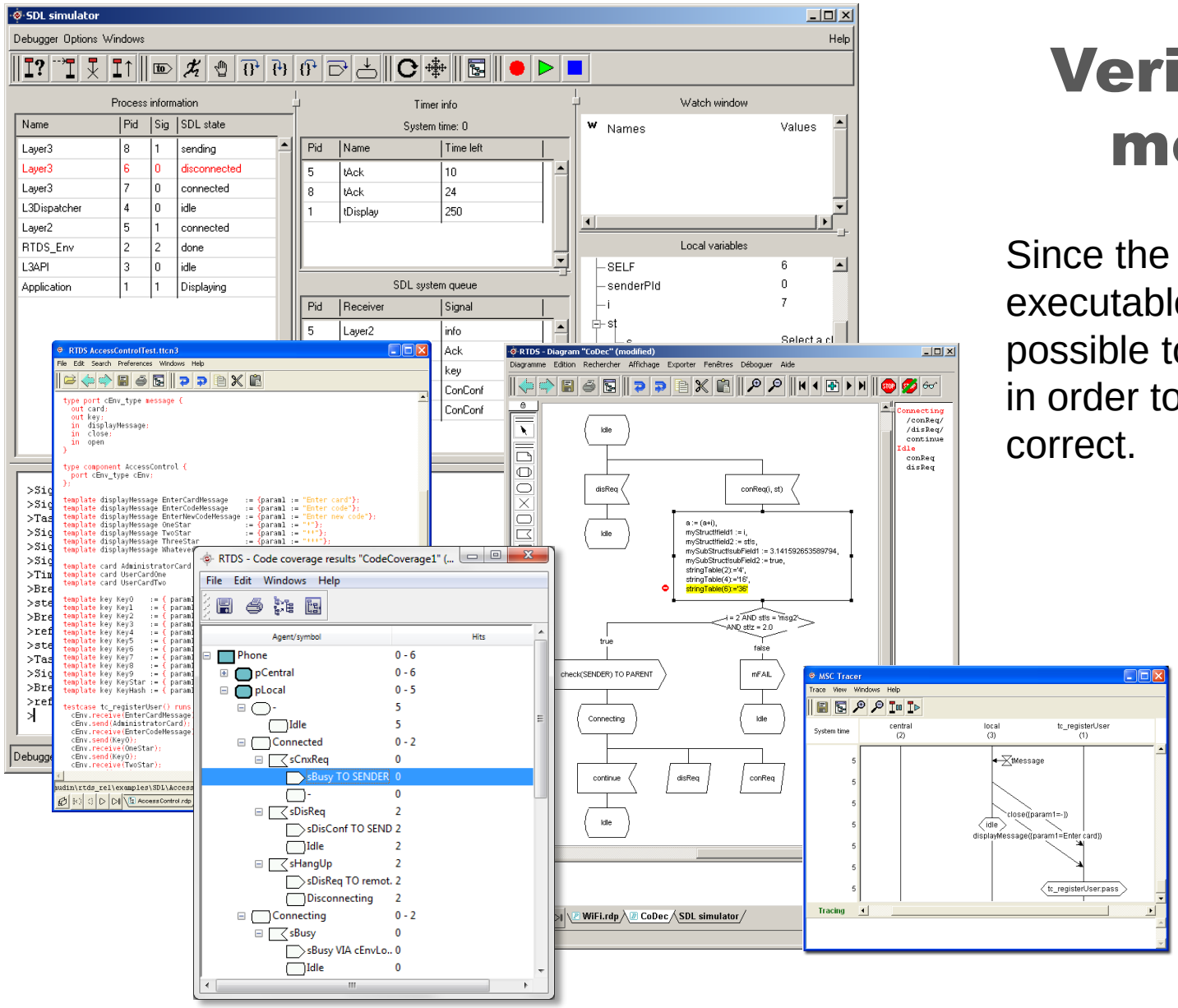
Requirements for a good modelling language

- The abstract model must be platform independent, as its name states.
- The abstract model must be translatable to an execution platform.
- For that purpose, the abstract model is based on a virtual machine offering:
  - Some **basic services.**
  - An execution **semantic**.

SDL international standard is the best candidate to model event driven systems.



Key features for Model Based Testing capabilities



Verify the model

Since the model is executable, it is possible to simulate it in order to verify it is correct.

Requirements for a good testing language

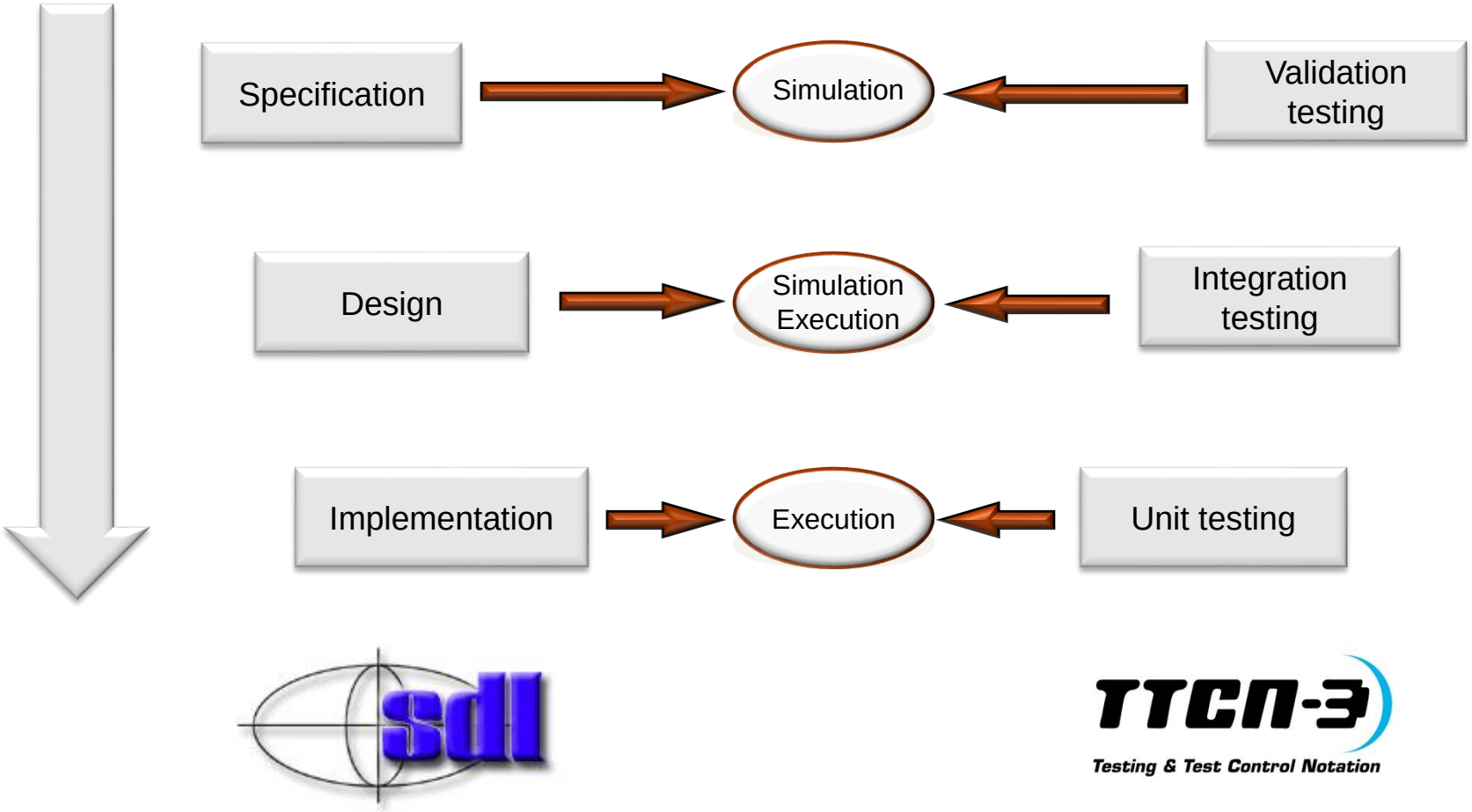
- Relies on the same basic services as SDL:
  - Messages
  - Procedures
  - Timers
  - Parallel execution
- TTCN-3 international standard:
  - Data types definitions or ASN.1,
  - Templates definitions,
  - Test cases,
  - Verdict,
  - Execution control.

TTCN-3
Testing & Test Control Notation

ETSI
World Class Standards

ITU International Telecommunication Union

Same level of abstraction



Model analysis technologies

- Partnership with specialized labs:
  - Exhaustive simulation,
  - **Symbolic resolution**.
- Properties:
  - **Model coverage**,
  - Static or dynamic property:
    - Property verification,
    - Test objectives.

PRAGMAList

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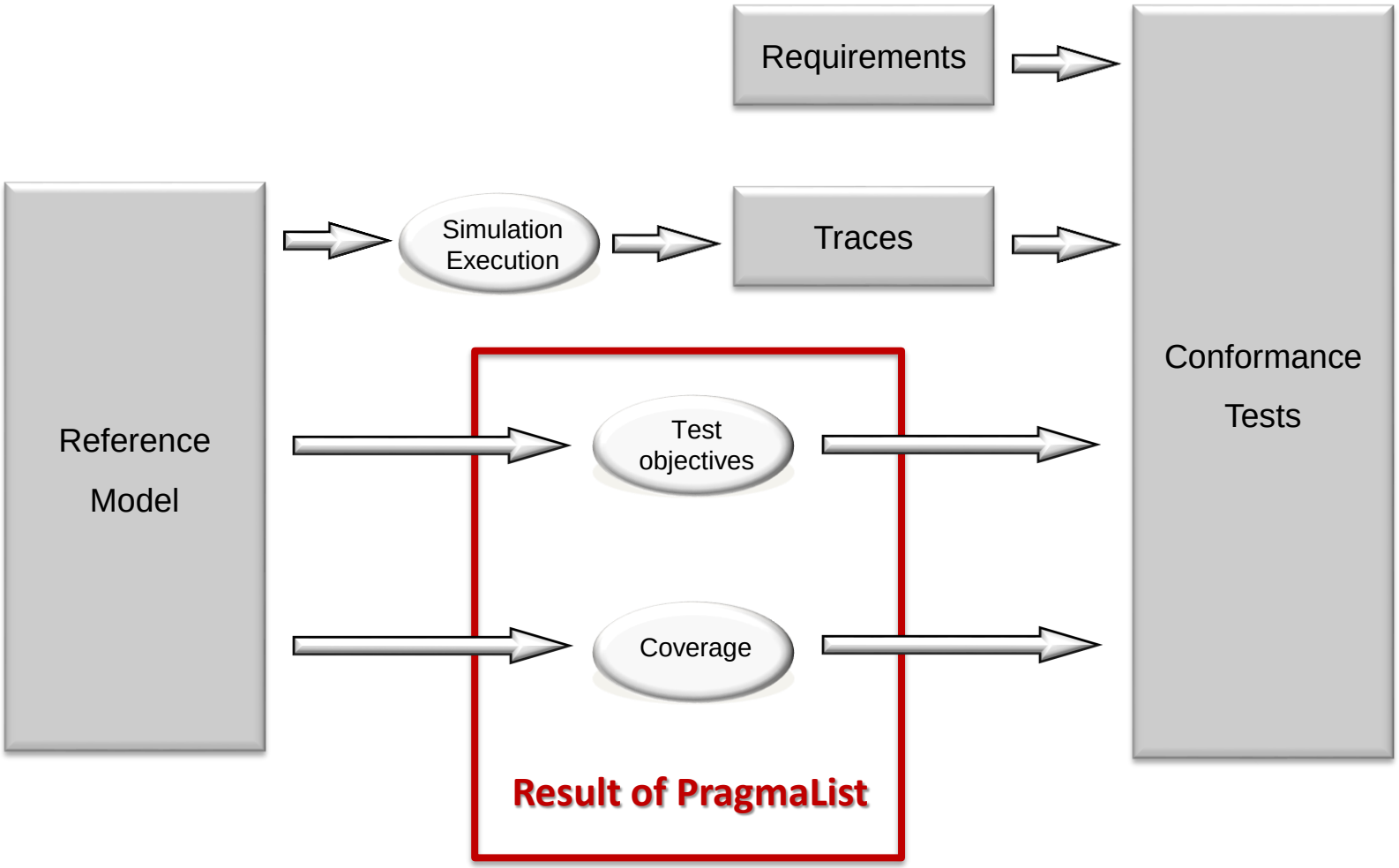
LAAS

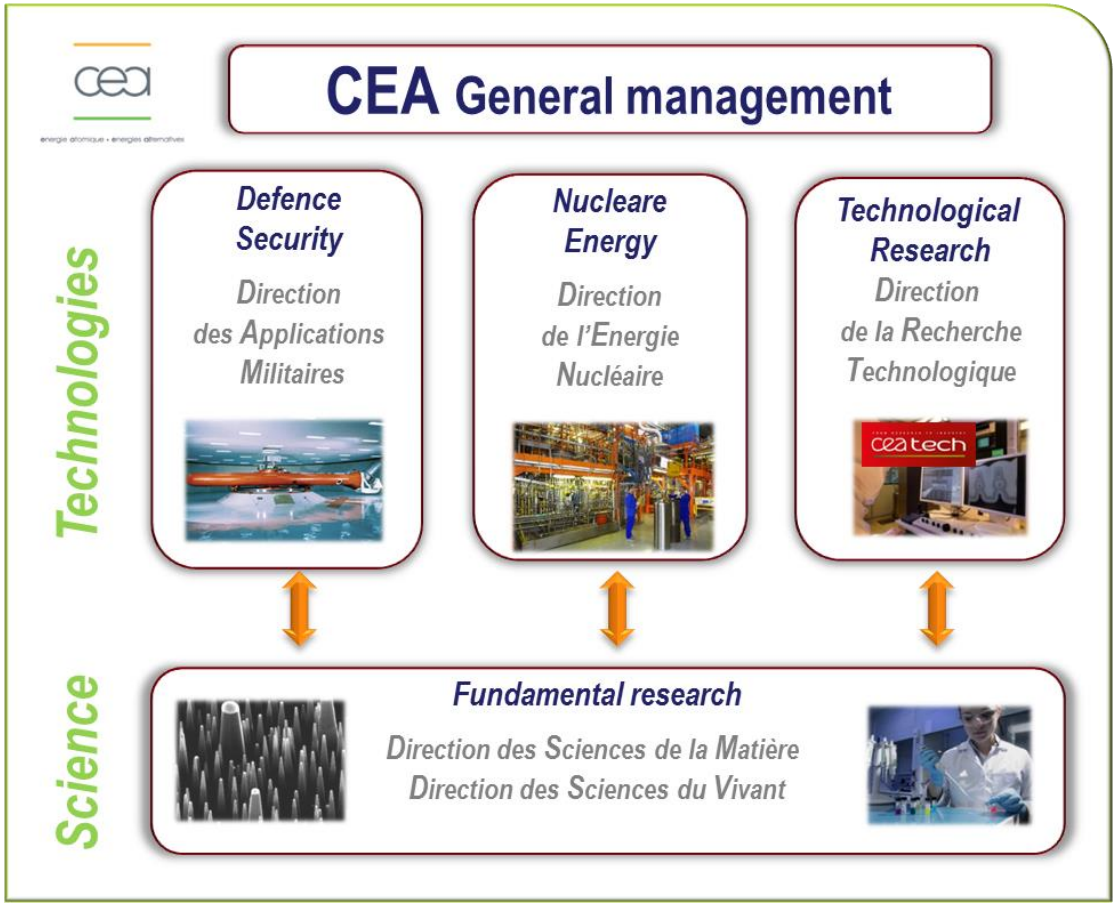
Verimag

Reference testing



CEA – A major European RTO

- 16 000 people
- 10 centers in France
- Budget: 4.3€ billions
- 1 600 patents
- 4 000 publications/year
- 150 startup created since 1984



cea tech

INSTITUTES

leti

1967 - Grenoble

Laboratoire d'Electronique et des Technologies de l'Information — 1800 pers.

Micro &nanotechnologies and systems intégration

list

2003 - Paris Sud

Laboratoire d'Intégration des Systèmes et des Technologies — 700 pers.

Digital systems

liten

2005 - Grenoble / Chambéry

Laboratoire d'Innovation pour les Technologies des Energies nouvelles et les Nanomatériaux — 1100 pers.

New energy technologies / Nanomaterials

Solaire

ines INSTITUT NATIONAL DE L'ENERGIE SOLAIRE

CEA LIST R&D PROGRAMMES

SYSTEMS OF SYSTEMS

ADVANCED MANUFACTURING

Systems for industry

- Robotics
- Virtual reality
- Non destructive testing
- Vision

EMBEDDED SYSTEMS

- Software engineering
- Safety & security
- Computing architectures
- Communication and interfaces

AMBIENT INTELLIGENCE

Sensing systems and big data

- Sensors, instrumentation
- Metrology
- Big data and multimedia

Diversity principle

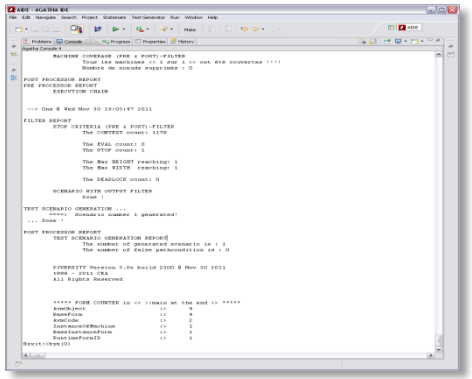
Model:
- Several execution semantics: Synchronous / Asynchronous State machine / Dataflow
- Several communication semantics: Rendez vous / FIFO / …

Coverage criteria:
- states / transitions
- MC/DC

Structural constraints:
- nb of tests,
- size of a test

DIVERSITY - xLIA

Test cases

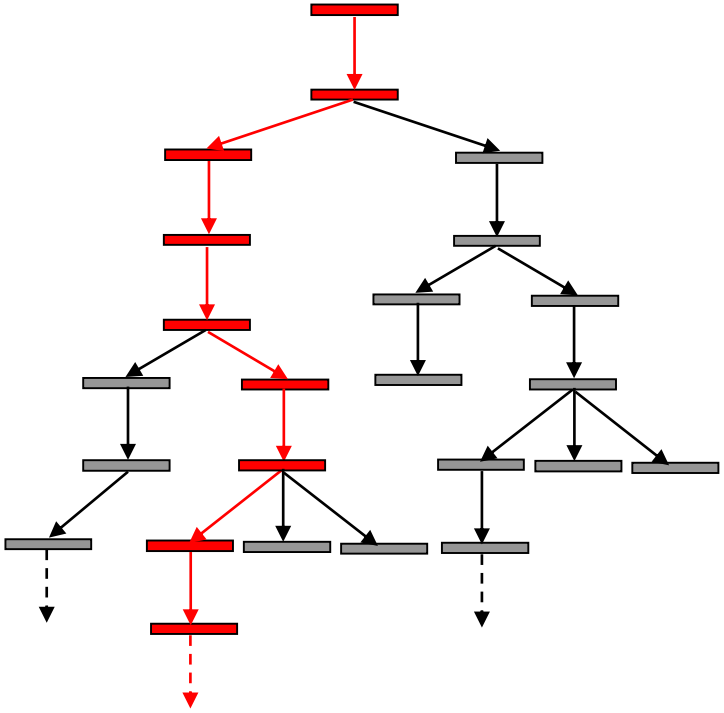


Coverage information

Diversity kernel

Symbolic simulation of the model:

- Defines **symbolic behaviours**, i.e. **equivalence classes** of numerical behaviours of the system.
- Represented as a tree.
- Each path = a distinct symbolic behaviour.
- Random choice of a numerical behaviour for each equivalence class → **Test Case**



Numerical Test Case

Diversity outputs

Generate a set of scenarios (i.e. test cases) *wrt* a specific objective.

This set is reduced with regard to redundancy.

Moreover, during the analysis phase, the tool can detect:

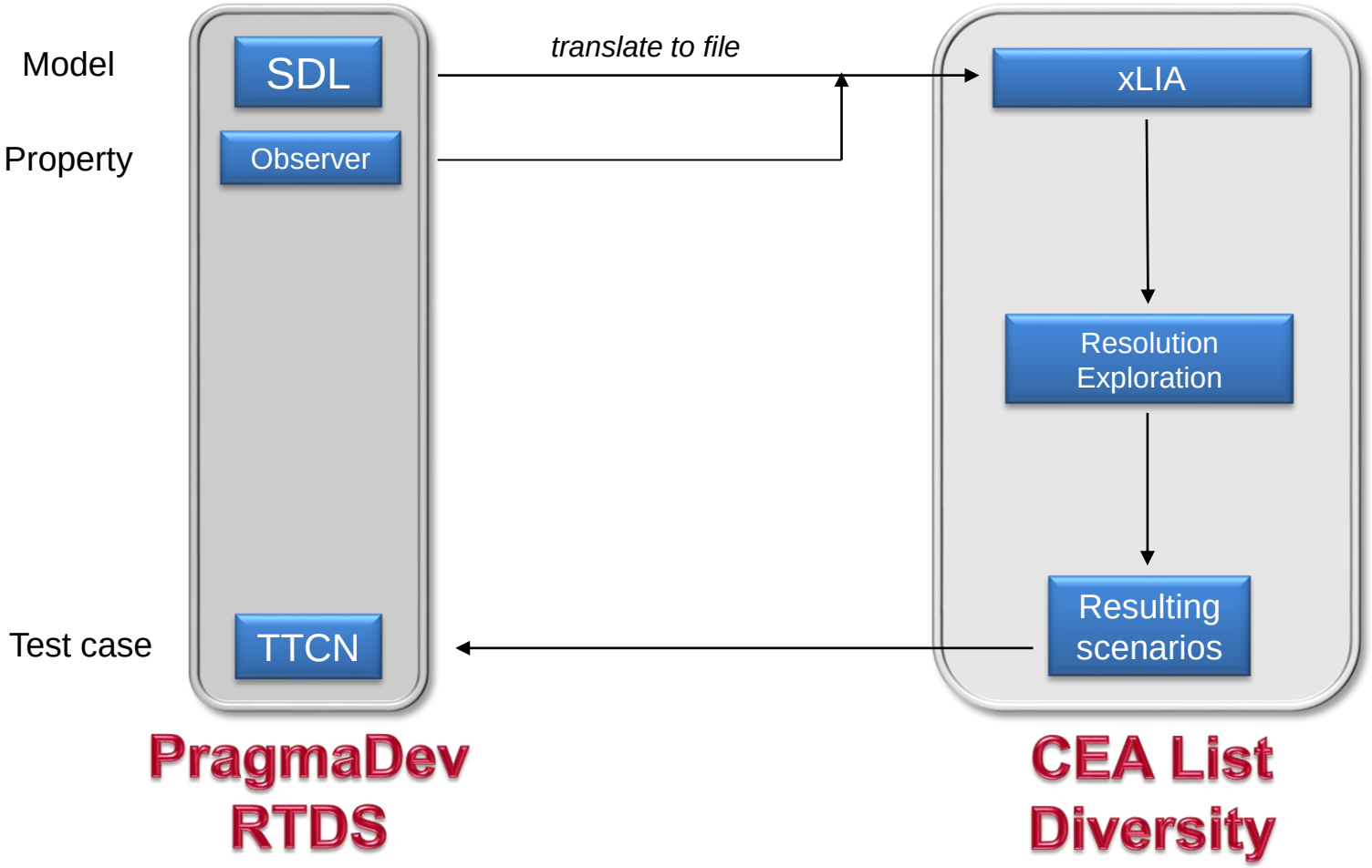
- **inconsistancies** among data types,
- **dead locks**,
- **dead parts** of the model,
- …

The project in four steps.

- **Step 1 : SDL to xLIA translation rules :**
  - Write the translation rules to convert SDL to xLIA.
- **Step 2 : SDL to xLIA translator :**
  - Write the xLIA generator from an SDL model.
- **Step 3 : Diversity adaptation to support SDL semantic :**
  - Work on SDL communication semantic,
  - Work on SDL timer semantic.
- **Step 4 : TTCN-3 formats output generation :**
  - TTCN-3 test cases formatting to be supported by RTDS.

xLIA is the CEA List Diversity file format to describe the model

Architecture



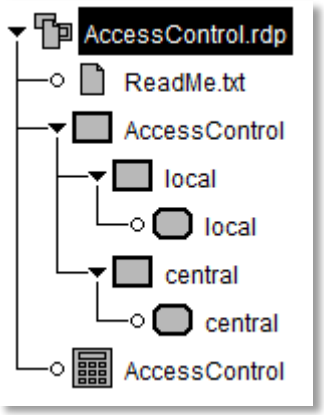
Four types of targets

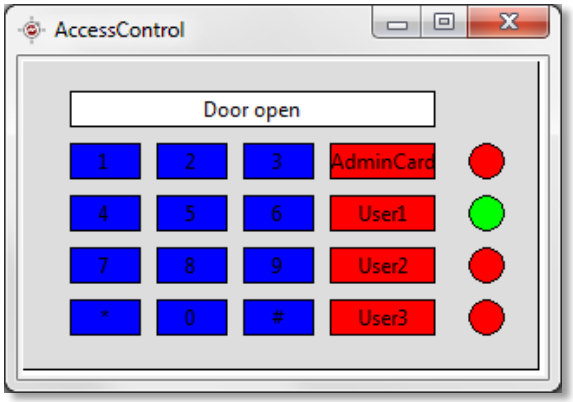
- **Code coverage :**
  - To generate the minimum number of test cases that cover all transitions.
- **Transition :**
  - To generate a test case that covers a specific transition in the SDL model.
- **Property :**
  - To generate the test cases verifying a static property (process state, variable value, …).
- **Observer :**
  - To generate the test cases verifying a dynamic property (succession of action or temporal rules). A dynamic property is defined as a state machine called observer.

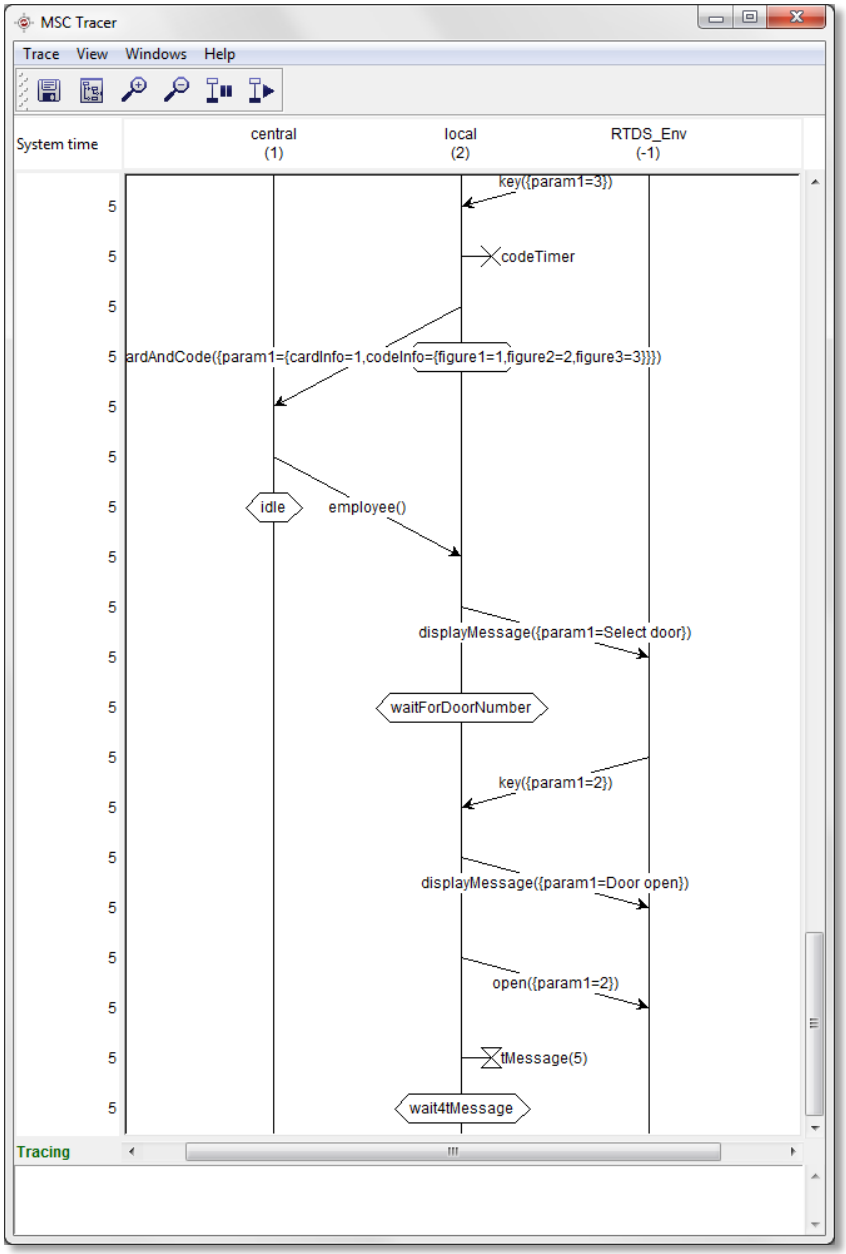
Demonstration

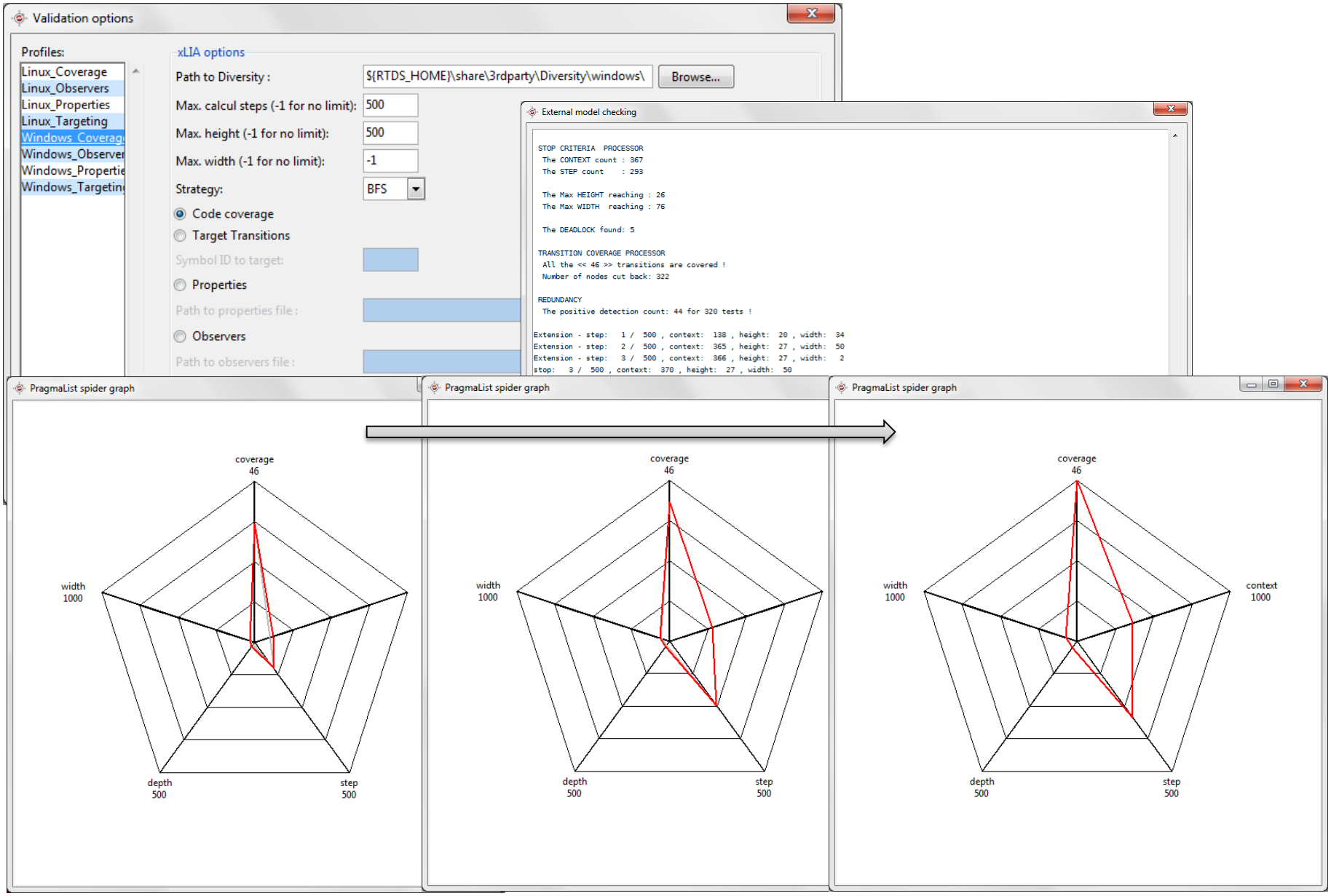
An Access Control System:

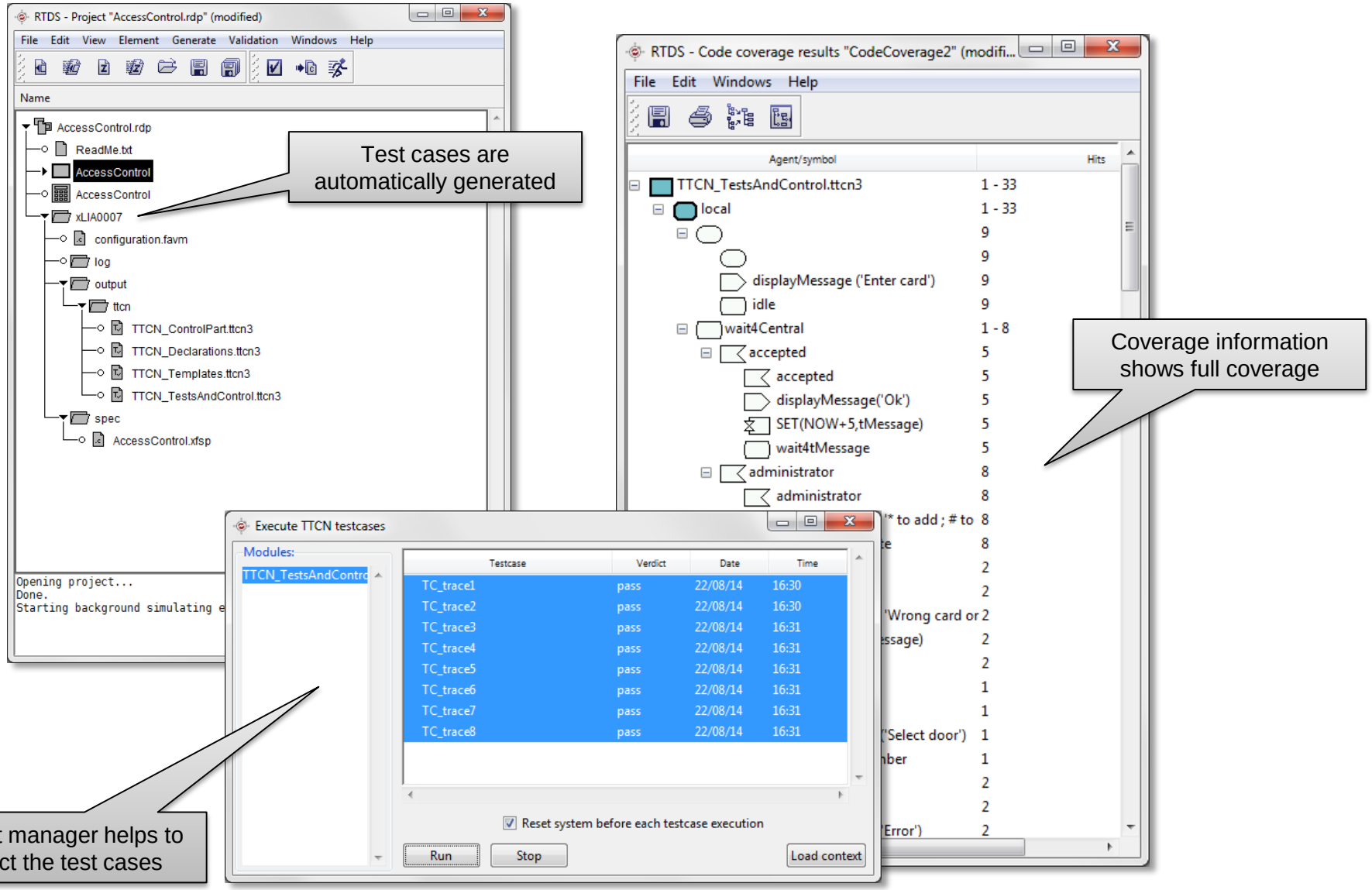
- 2 state machines
- A card input with a 0..65535 integer as parameter
- A key input with a 0..11 integer as parameter








Validation options
Profiles:
Linux_Coverage
Linux_Observers
Linux_Properties
Linux_Targeting
Windows_Coverag
Windows_Observer
Windows_Propertie
Windows_Targetin
xLIA options
Path to Diversity :
${RTDS_HOME}\share\3rdparty\Diversity\windows\
Browse...
Max. calcul steps (-1 for no limit):
500
Max. height (-1 for no limit):
500
Max. width (-1 for no limit):
-1
Strategy:
BFS
Code coverage
Target Transitions
Symbol ID to target:
Properties
Path to properties file :
Observers
Path to observers file :
External model checking
STOP CRITERIA PROCESSOR
The CONTEXT count : 367
The STEP count : 293
The Max HEIGHT reaching : 26
The Max WIDTH reaching : 76
The DEADLOCK found: 5
TRANSITION COVERAGE PROCESSOR
All the << 46 >> transitions are covered !
Number of nodes cut back: 322
REDUNDANCY
The positive detection count: 44 for 320 tests !
Extension - step: 1 / 500 , context: 138 , height: 20 , width: 34
Extension - step: 2 / 500 , context: 365 , height: 27 , width: 50
Extension - step: 3 / 500 , context: 366 , height: 27 , width: 2
stop: 3 / 500 , context: 370 , height: 27 , width: 50
PragmaList spider graph
coverage 46
width 1000
depth 500
step 500
PragmaList spider graph
coverage 46
width 1000
depth 500
step 500
PragmaList spider graph
coverage 46
width 1000
context 1000
depth 500
step 500


RTDS - Project "AccessControl.rdp" (modified)
File Edit View Element Generate Validation Windows Help
Name
AccessControl.rdp
ReadMe.txt
AccessControl
AccessControl
xLIA0007
configuration.favm
log
output
ttcn
TTCN_ControlPart.ttcn3
TTCN_Declarations.ttcn3
TTCN_Templates.ttcn3
TTCN_TestsAndControl.ttcn3
spec
AccessControl.xfsp
Opening project...
Done.
Starting background simulating e
Test cases are automatically generated
RTDS - Code coverage results "CodeCoverage2" (modifi...
File Edit Windows Help
Agent/symbol
Hits
TTCN_TestsAndControl.ttcn3 1 - 33
local 1 - 33
9
9
displayMessage ('Enter card') 9
idle 9
wait4Central 1 - 8
accepted 5
accepted 5
displayMessage('Ok') 5
SET(NOW+5,tMessage) 5
wait4tMessage 5
administrator 8
administrator 8
Coverage information shows full coverage
Execute TTCN testcases
Modules:
TTCN_TestsAndContro
Testcase Verdict Date Time
TC_trace1 pass 22/08/14 16:30
TC_trace2 pass 22/08/14 16:30
TC_trace3 pass 22/08/14 16:31
TC_trace4 pass 22/08/14 16:31
TC_trace5 pass 22/08/14 16:31
TC_trace6 pass 22/08/14 16:31
TC_trace7 pass 22/08/14 16:31
TC_trace8 pass 22/08/14 16:31
Reset system before each testcase execution
Run
Stop
Load context
A Test manager helps to select the test cases

CEA List - Diversity

- Exploration time is always the same (10 secondes) whatever are the message parameter ranges.

Verimag - IF toolbox

- Exhaustive exploration
- Exploration time depends on message parameter range.

Card range \ Digit range	0..1	0..2	0..3
0..1	13	126	721
0..2	38	316	2169
0..3	64	650	28234

Time to explore the model in seconds

On-going use cases

- SNCF: Radio Block Center (RBC)
- Alstom Belgium: Radio Gateway
- Alstom France: Passenger exchange
- Airbus: Air Traffic Control (ATC)
- Other: Secure transactions

Model Based Testing solution

- Integrated tool chain
- Non dedicated model
- Efficient symbolic kernel
  - Test automation
  - Reduce the number of test cases
  - Early in the development process