"PyNuSMV: NuSMV as a Python Library "

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PyNuSMV: NuSMV as a Python Library

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1. Objectives

Main goal: a framework for experimenting with BDD-based model-checking algorithms.

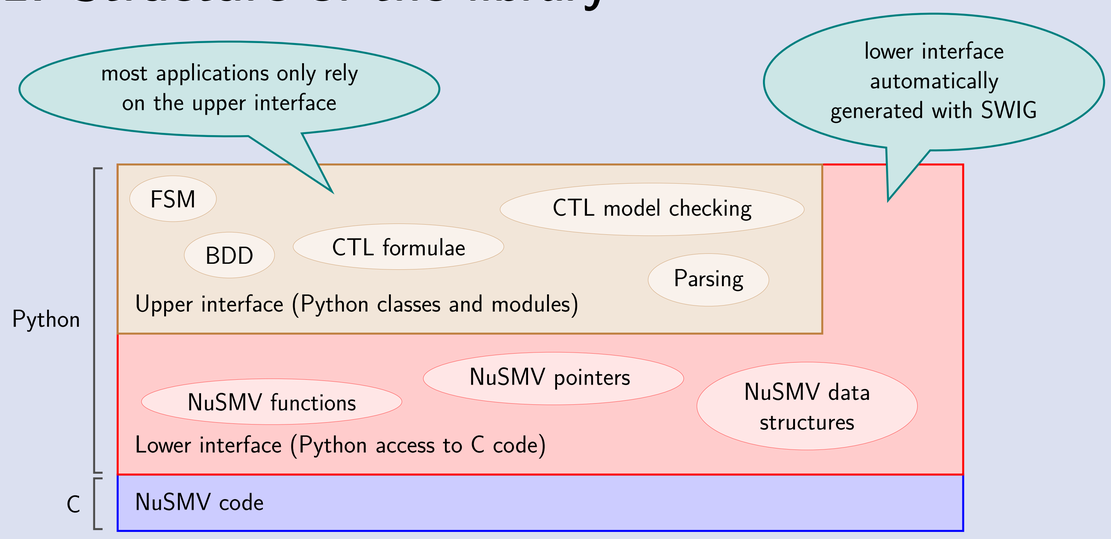
+ Access to **NuSMV features**: modeling language, BDD library, model checking, etc.

+ A **high-level language**: hide low-level mechanisms such as memory management.

⇒ **PyNuSMV:** a Python platform to implement new logics and experiment with custom model-checking algorithms based on NuSMV.

Already used for prototyping ARCTL, CTLK, ATL model checking and rich counter-examples.

2. Structure of the library



3. Example: CTL model checking

```
1  def main(modelPath):
2      init_nusmv()
3      fsm = BddFsm.from_filename(modelPath)
4      propDb = glob.prop_database()
5      for prop in propDb:
6          if prop.type == propTypes['CTL']:
7              spec = prop.exprcore
8              violating = fsm.init & ~eval_ctl(fsm, spec)
9              print('Specification',str(spec), 'is', str(violating.is_false()))
10             # We could generate counter-examples here
11     deinit_nusmv()
```

```
1  def eval_ctl(fsm, spec):
2      ...
3      elif spec.type == parser.IFF:
4          left = eval_ctl(fsm, spec.car, context)
5          right = eval_ctl(fsm, spec.cdr, context)
6          return (left & right) | (~left & ~right)
7      elif spec.type == parser.AF:
8          left = eval_ctl(fsm, spec.car, context)
9          return ~eg(fsm, ~left)
10     ...
```

$\phi \iff \psi = (\phi \wedge \psi) \vee (\neg\phi \wedge \neg\psi)$

AF $\phi = \neg$EG $\neg\phi$

```
1  def fixpoint(funct, start):
2      old = start
3      new = funct(start)
4      while old != new:
5          old = new
6          new = funct(old)
7      return old
8  def eg(fsm, phi):
9      return fixpoint(lambda Z: psi & fsm.pre(Z),
10                     BDD.true(fsm.bddEnc.DDmanager))
```

EG $\phi = \nu Z.\phi \wedge \mathrm{Pre}(Z)$

4. Example: ATL model checking

```
1  def eval_atl(fsm, spec):
2  ...
3      elif type(spec) is CAG:
4          return ~ceu(fsm,
5                      {atom.value for atom in spec.group},
6                      BDD.true(fsm.bddEnc.DDmanager),
7                      ~eval_atl(fsm, spec.child))
8  ...
```

$[\Gamma]\mathrm{G}\ \phi = \neg\langle\Gamma\rangle\ \mathrm{True\ U}\ \neg\phi$

```
1  def ceu(fsm, agents, phi, psi):
2      return fp(lambda Y : psi |
3                (phi & fsm.pre_strat(Y, agents)),
4                BDD.false(fsm.bddEnc.DDmanager))
```

$\langle\Gamma\rangle\ \phi\ \mathrm{U}\ \psi = \mu Z.\psi \vee (\phi \wedge \mathrm{Pre}_{\langle\Gamma\rangle}(Z))$

```
1  def pre_strat(self, states, agents):
2      gamma_cube = self.inputs_cube_for_agents(agents)
3      ngamma_cube = self.bddEnc.inputsCube - gamma_cube
4      return (~(self.weak_pre(~states).forsome(ngamma_cube))
5              & self.weak_pre(states)
6              ).forsome(gamma_cube)
```

$\mathrm{Pre}_{\langle\Gamma\rangle}(Z) = \exists a_\Gamma.\overline{\exists a_\Gamma \mathrm{Pre}_{SI}(\overline{Z})}$

5. Evaluation: CTL model checking

same algorithm (C/Python)

Model	**NuSMV** (seconds)	**PyNuSMV** (seconds)
counter	0	0
mutex	0.001	0.009
dme1	0.275	0.288
gas-nq7	8.913	11.027
msi_wtrans	23.285	23.652
dme1-16	61.246	64.733
ftp3	75.607	78.771
key10	100.614	103.606

1–6% overhead on large models

6. Advantages and drawbacks

+ Access to **all NuSMV functionalities** through lower or upper interface.

+ **High-level language** with garbage collection, etc.

+ **Less code to write**: access to model parsing, evaluating simple expressions, etc.

– **Stick to NuSMV architecture**, not written to be used as a library.

– No unified **error management**.

7. Future work

- Supporting **more NuSMV features**: SAT, LTL model checking, model simulation, etc.
- A **homogeneous error management** in the upper interface with Python exceptions.

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