Lab on Behavior Models and Verification

NuXMV System
NuXMV

- State-of-the-art symbolic model checker
  - Recall: Spin is an explicit model checker
- Based on NuSMV, extending it
- Originally developed at Carnegie Mellon University (SMV)
- Special input language, CTL properties
  - Uses OBDDs for states' manipulation
  - Both synchronous and asynchronous systems may be described
The SMV Input Language

- Parallel assignment syntax
  - In each step all variables are reassigned
    - Issues of circular dependencies, ...
  - Allows for easy OBDD modeling
- Initial values and “next” values are specified
Example I.

MODULE main
VAR
    request : boolean;
    state : {ready,busy};
ASSIGN
    init(state) := ready;
    next(state) := case
        state = ready & request : busy;
        TRUE : {ready,busy};
    esac;
SPEC
    AG(request -> AF state = busy)
Example II.

```
MODULE counter_cell(carry_in)
VAR
  value : boolean;
ASSIGN
  init(value) := FALSE;
  next(value) := value xor carry_in;
DEFINE
  carry_out := value & carry_in;

MODULE main
VAR
  bit0 : counter_cell(TRUE);
  bit1 : counter_cell(bit0.carry_out);
  bit2 : counter_cell(bit1.carry_out);

SPEC AF(bit2.carry_out)
```
Types

- boolean
- enum
- word – specifying bit width
  - e.g. word[3] ➔ three-bit range, i.e., 0-7
  - Cannot create unions thereof ➔ use integer sets instead
- integer
- real – rational numbers 😊
- arrays, wordarrays, intarrays (unbounded arrays)
  - nesting of types
- sets – limited, just sets of boolean, integer, symbolic and mixed enums
Propositional way

**FAIRNESS**
- A fairness constraint – mostly used with running

**INIT**
- Initial value of local variables

**TRANS**
- Definition of transition relation
  - $\text{next(output)} = \neg \text{input} \mid \text{next(output)} = \text{output}$

**INVAR**
- Conditions restricting valid states
The use of \texttt{INIT, TRANS} and \texttt{INVAR} NOT recommended

- "Logical absurdities (...) can lead to unimplementable descriptions"
- Resulting in systems with no transitions, etc.

However

- It may be flexible when translating from other languages to SMV
DEFINE – symbols definition

```
DEFINE

  start := state = 0 & timeout;
  finish := state = 3;
  request := case
    state = 0: 0;
    TRUE : 1;
  esac;
```
Modules

- Encapsulation of a group of declarations
  - Can be parametrized when reusing
  - Can contain instances of other modules
  - Example: see above

- A parameterless `main` module has to be in each program
Verification and simulation

- Properties inside models can be verified
  - \texttt{nuxmv model.smv}
  - All CTL properties specified inside the models are checked

- Or the model can be simulated
  - \texttt{nuxmv -int model.smv}
  - Interactively, randomly, or deterministically
Simulation

- `nusmv -int model.smv`
  - Starts the nuxmv in interactive model
- `go`
  - Prepares the model
- `pick_state -r`
  - Picks up initial state (-r randomly, -i interactively)
- `print_current_state -v`
  - Prints the current state (-v verbosely)
- `simulate -r -k 3`
  - Simulates randomly three steps
SMV Information

- The original tool and manual downloadable at http://www.cs.cmu.edu/~modelcheck/smv.html

- Implementations to use: NuSMV and NuXMV
  http://nusmv.fbk.eu/
  http://nuxmv.fbk.eu/

- NuXMV is newer and recommended