

First experiences in KIV formalisation&verification of medical protocols (illustrated with jaundice protocol)

Michael Balser, Mar Marcos

Plan

- KIV in a nutshell
- Formalisation
- Verification

KIV in a nutshell

- Advanced tool for the specification & verification of software
- Features:
 - modularity, user interaction, management tools
 - language:
 - algebraic+procedural specifications
 - rich set of programming constructs
 - for sequential programs: `:=`, `SKIP`, `ABORT`, `VAR`, `IF`, `WHILE`
 - for parallel programs: `||`, `AWAIT`, `OR`, `ATOM`

Formalisation

- Starting point:
 - intermediate Asbru model
 - informal semantics of Asbru constructs
- KIV extensions:
 - language:
 - new programming constructs for Asbru
 - `BREAK` (interrupts)
 - `||s` (synchronous execution)
 - `||a` (any order sequential execution)

Formalisation

plan-to-program mapping

- Translation based on plan-to-program mapping:
 - mapping of plan conditions
 - FILTER PRECONDITION ϕ body $\rightarrow$ AWAIT ϕ ; body
 - COMPLETE/ABORT CONDITION ϕ body $\rightarrow$ BREAK body IF ϕ
 - ACTIVATE MODE manual body $\rightarrow$ VAR time0=time, dt=[?] AWAIT time0+dt $\leq$ time; body

Formalisation

plan-to-program mapping (cont.)

- mapping of control structure
 - DO PARALLEL plan1 plan2... $\rightarrow$ plan1 ??? plan2...
 - DO ANY-ORDER plan1 plan2... $\rightarrow$ plan1 ||a plan2...
 - DO UNORDERED plan1 plan2... $\rightarrow$ plan1 ||s plan2...
- mapping of continuation specification
 - DO ..., WAIT-FOR planN, ... $\rightarrow$
VAR planN-completed IN
BREAK ... IF planN-state=completed
- mapping of specific options is done in an *ad hoc* way

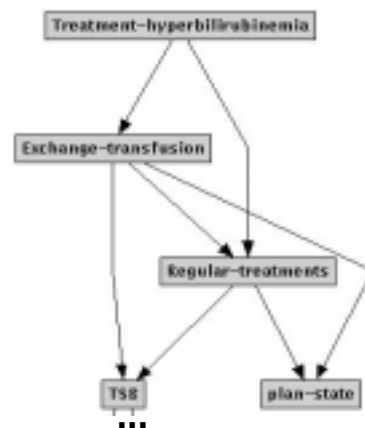
Formalisation

the treatment part of jaundice

- An example of formalisation: the treatment part of jaundice

– different modules:

- Treatment-hyperbilirubin.
- Exchange-transfusion
- Regular-treatments
- plan-state
- TSB
- ...and other specifications



Formalisation

the treatment part of jaundice (cont.)

– TSB specification:

- functions&axioms for treatment table, e.g. to derive the appropriate treatment:

```

25 ≤ a ∧ a ≤ 48 ∧ l < 12 →
get-bilirubin(set-age-level(tsb, a, l)) = observation;
...

```

– Regular-treatments specification:

- procedures for clinical actions, of automatic activation:

```

PLAN Prescribe-observation#(VAR time)
BEGIN
  Prescribe-observation
  SKIP
PLAN BODY
  VAR time0 = time, dt = [?] IN AWAIT time0 + dt ≤ time
  user-performed
END

```

Formalisation

the treatment part of jaundice (cont.)

or manual activation:

```

PLAN Prescribe-observation-manual (VAR time)
BEGIN
  Prescribe-observation
  VAR time0=time, dt=[?] IN AWAIT time0+dt≤time;
  CONDITIONS activate-mode: manual
  SKIP
PLAN BODY
  VAR time0=time, dt=[?] IN AWAIT time0+dt≤time
  user-performed
END

```

• procedures using the previous ones:

```

PLAN Observation (VAR tsb, time, Observation-st)
BEGIN
  CONDITIONS
    AWAIT get-bilirubin(tsb)≠observation;
    fine preconditions: bilirubin=observation;
  PBREAK BEGIN
    abort-conditions: bilirubin≠observation
    Prescribe-observation#(;time);
PLAN BODY
    observation-st:=completed
    Prescribe-observation
  END
  IF get-bilirubin(tsb)≠observation
END;

```

Formalisation

the treatment part of jaundice (cont.)

• and procedure for Regular-treatments

```

PLAN Regular-treatments# (VAR tsb, time, Regular-treatments-st,
  Phototherapy-intensive-act)
PLAN BODY
BEGIN
  do unordered, wait-for all
    ... Feeding-alternatives
    AWAIT get-bilirubin(tsb)≠transfusion;
    PBREAK BEGIN
      do any-order, retry-aborted-subplans=yes, wait-for Observation
      Feeding-alternatives#(time)
      ||s Phototherapy-intensive
      ||s Phototherapy-normal-prescription
      VAR Observation-st=completed IN BEGIN
        PBREAK WHILE true do
          BEGIN
            Phototherapy-intensive#(...) OR ...
            OR Observation#(;tsb, time, Observation-st)
          END
        IF Observation-st=completed
      END
    END ...

```

Formalisation

Conclusions

- Current state: the treatment part of jaundice has been formalised, but
 - translations are sometimes *ad hoc*
 - no proper translation for parallel plans (for the moment)
 - Asbru plans are difficult to recognise

Formalisation

Conclusions (cont.)

- Conclusions of the formalisation
 - translation of intermediate Asbru models into KIV is feasible
 - current KIV version is almost sufficient
- Next steps
 - study more general translation rules
 - continue with the formalisation of the diagnosis part of jaundice
 - continue with KIV extensions

Verification

...time for Michael!!!