Erly Marsh - a Model-Based Testing tool

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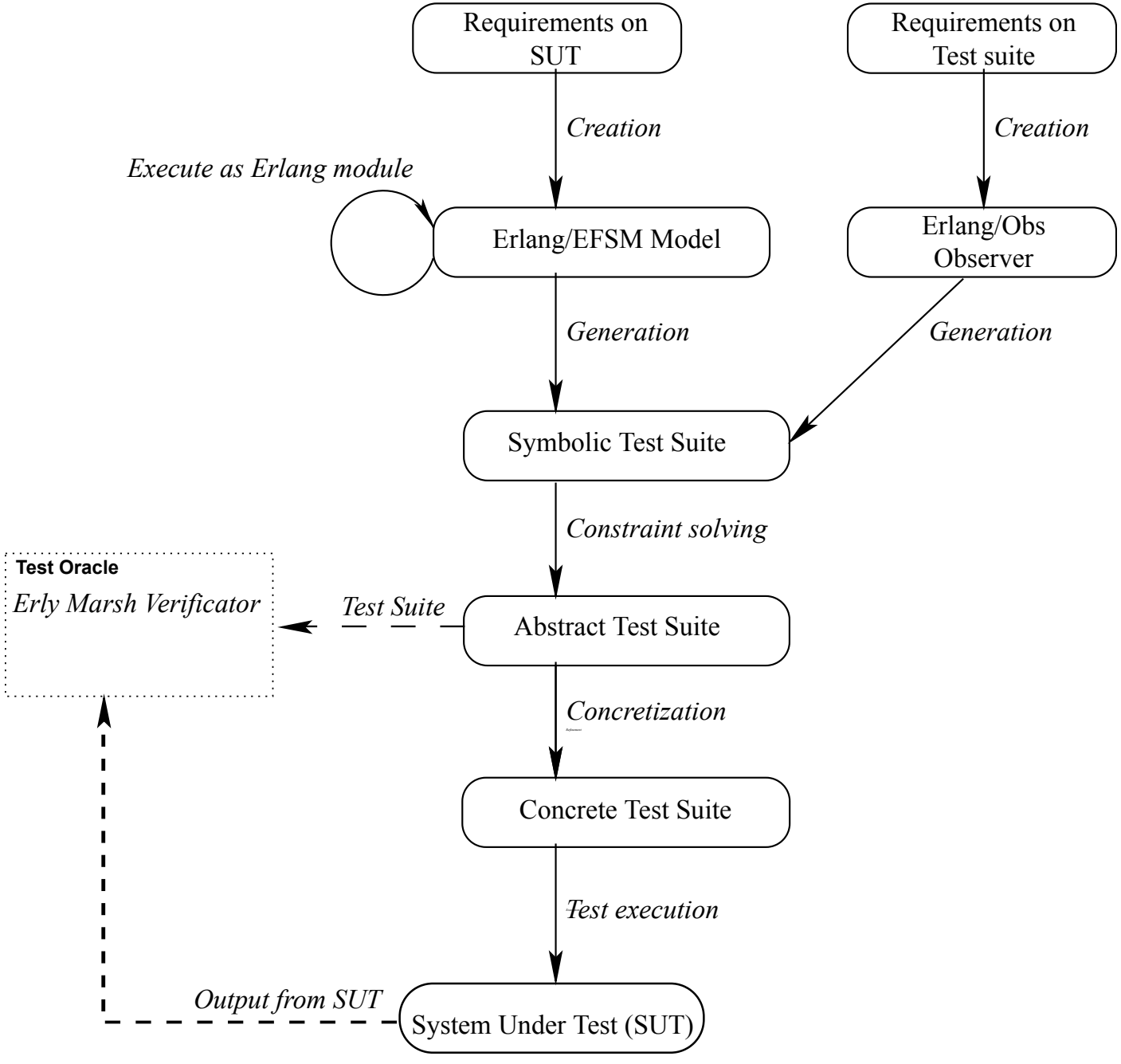
Motivation

- Mobile Arts
  - Develops server software for mobile telecom operators (Location server, SMSC etc.)
  - Implementations rather big and complicated
  - Experienced developers - but no testers
- How and what to test ?
  - Identified set of core modules in the Location server
  - Dialyzer runs revealed close to no problems
  - Manual test suite was running OK
  - So, everything was OK ?
- **NO!** (I thought)

Why ?

- Lots of the functionality not tested - in core modules and elsewhere
- Products **must** always be *operational* and limit *interference* with other network entities
- Model-Based Testing:
  - Captures *functional* requirements
  - Construct formal *executable* model
  - Test suite *generated* as execution of traces
  - Tool support enables generation of *very large* test suites
  - Implemented in several tools (Qtronic, SpecExplorer, ...)
- Started to develop my own tool - Erly Marsh


Requirements on SUT
Requirements on Test suite
Creation
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Execute as Erlang module
Erlang/EFSM Model
Erlang/Obs Observer
Generation
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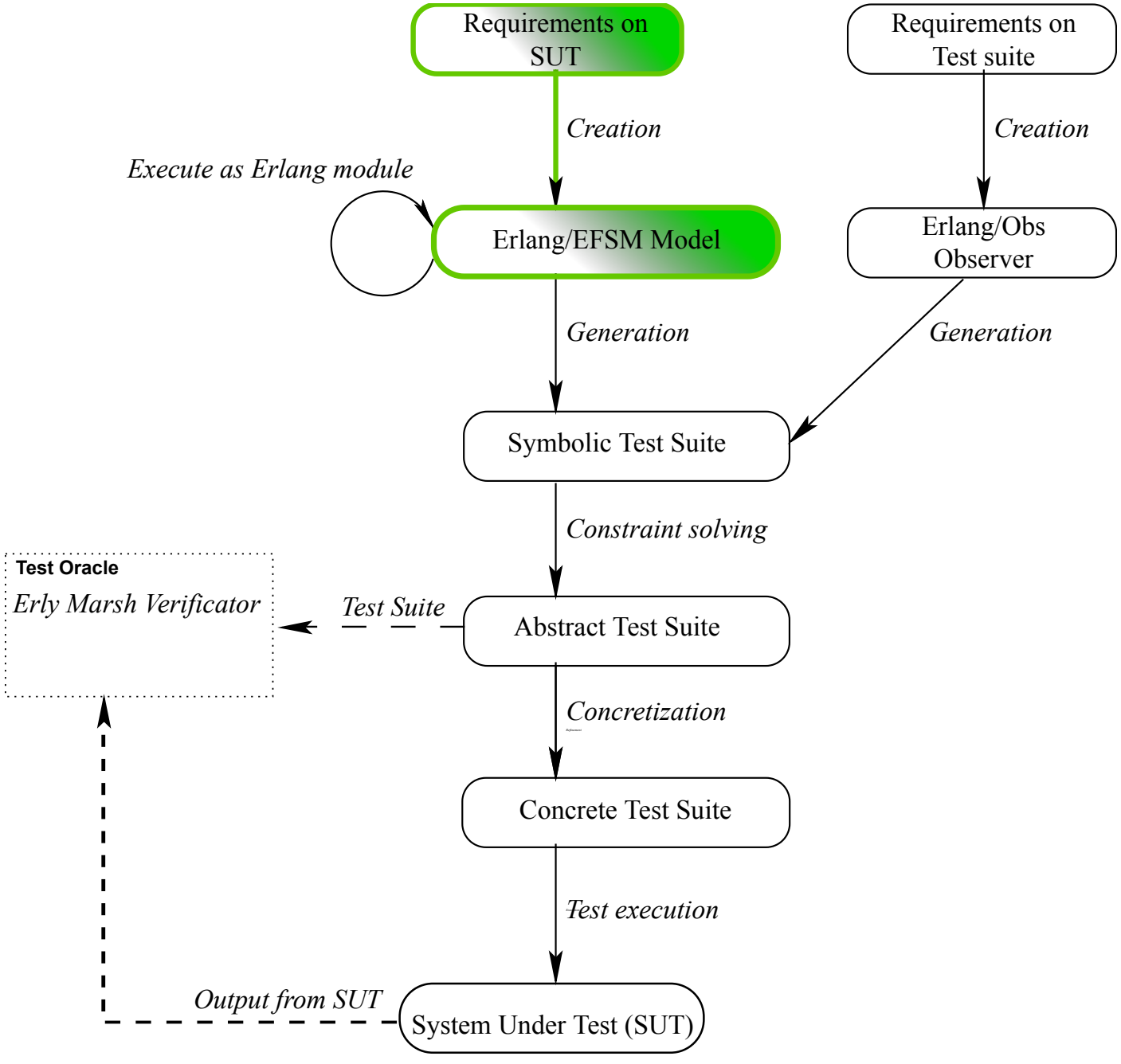
Symbolic Test Suite
Constraint solving
Test Oracle
Erly Marsh Verificator
Test Suite
Abstract Test Suite
Concretization
Concrete Test Suite
Test execution
Output from SUT
System Under Test (SUT)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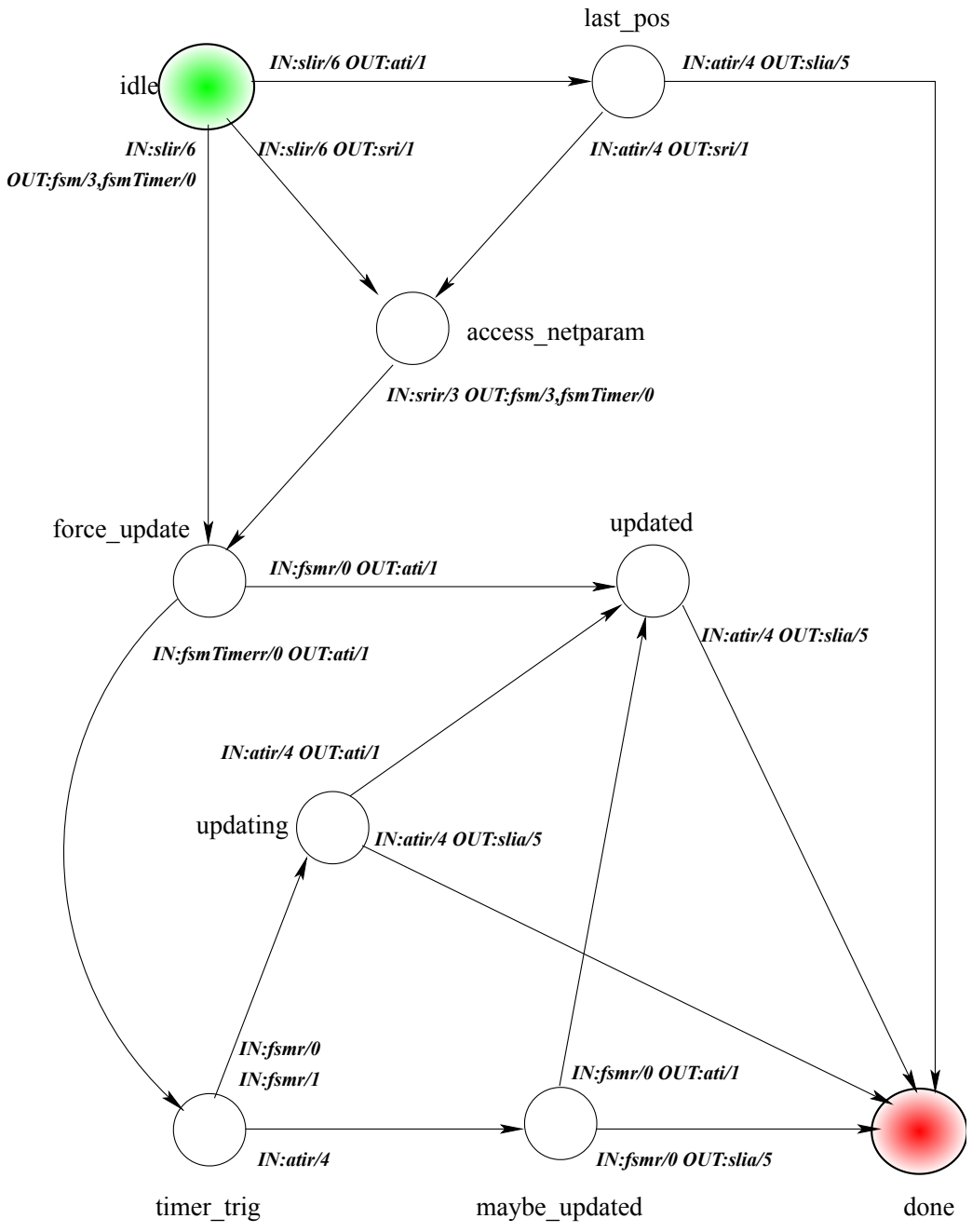
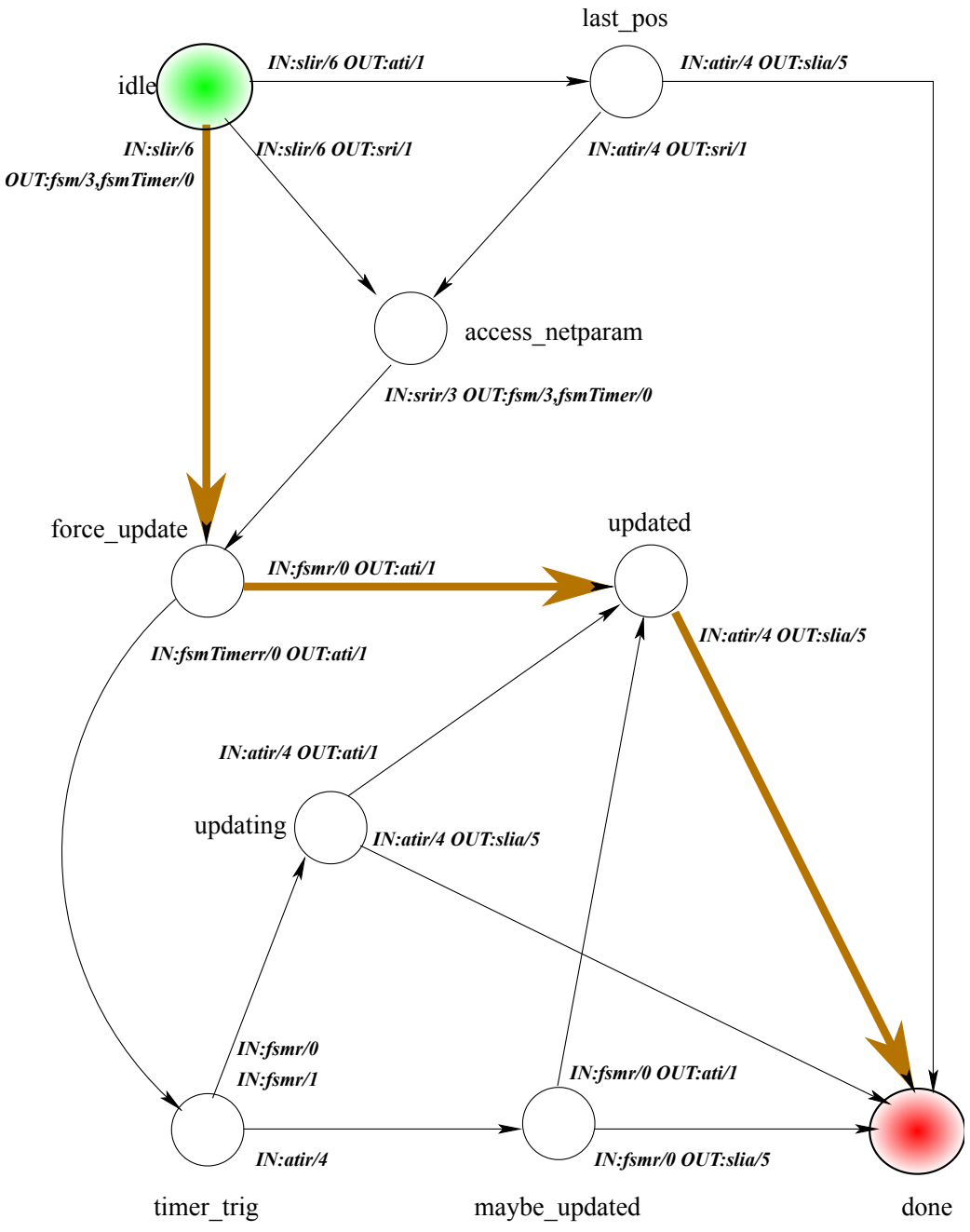
Modeling Language

- **Idea:**
  - Represent *abstract* view of System Under Test (SUT)
  - Cover *functional* properties
  - Specifically protocols, i.e., modeled by *state machines*
  - Based on Erlang:
    - Suitable constructs: pattern matching, dynamic typing, single assignment variables, ...
    - Lower learning threshold for Erlang developers
    - Allows reuse of Erlang tool infrastructure
- **Approach:**
  - Introduce Erlang/EFSM as a specification language


last_pos
idle
IN:slir/6 OUT:ati/1
IN:atir/4 OUT:slia/5
IN:slir/6
OUT:fsm/3,fsmTimer/0
IN:slir/6 OUT:sri/1
IN:atir/4 OUT:sri/1
access_netparam
IN:srir/3 OUT:fsm/3,fsmTimer/0
force_update
updated
IN:fsmr/0 OUT:ati/1
IN:fsmTimerr/0 OUT:ati/1
IN:atir/4 OUT:slia/5
IN:atir/4 OUT:ati/1
updating
IN:atir/4 OUT:slia/5
IN:fsmr/0
IN:fsmr/1
IN:fsmr/0 OUT:ati/1
IN:atir/4
IN:fsmr/0 OUT:slia/5
timer_trig
maybe_updated
done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IN:slir/6
OUT:fsm/3,fsmTimer/0
IN:slir/6 OUT:sri/1
IN:atir/4 OUT:sri/1
access_netparam
IN:srir/3 OUT:fsm/3,fsmTimer/0
force_update
updated
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IN:atir/4 OUT:slia/5
IN:atir/4 OUT:ati/1
updating
IN:atir/4 OUT:slia/5
IN:fsmr/0
IN:fsmr/1
IN:fsmr/0 OUT:ati/1
IN:atir/4
IN:fsmr/0 OUT:slia/5
timer_trig
maybe_updated
done

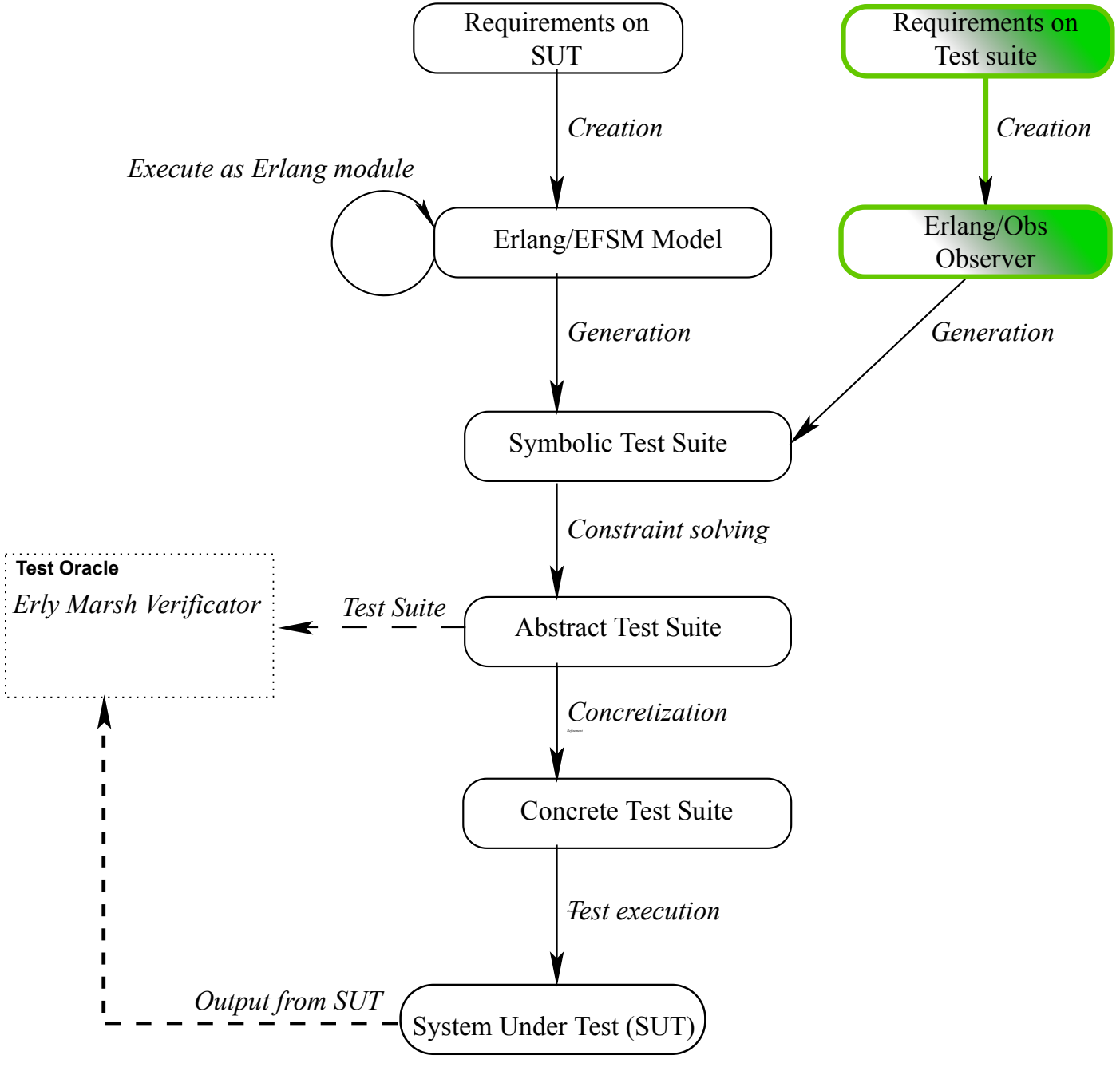
Erlang/EFSM transition clause

```
idle(slir,MSISDN,LocType,MaxAge,SMSTextType,NetPar,EnforcePSI)
  when EnforcePSI==false,
       hlrlocMethod(MSISDN)==ati ->
    if
      is_record(NetPar,netparam) ->
        send_fsm(NetPar),
        fsmTimerr(),
        {next_state,force_update};
      true ->
        send_sri(MSISDN),
        {next_state,access_netparam}
    end.

send_fsm(NetP) ->
    fsm(NetP#netparam.mscid,NetP#netparam.imsi,NetP#netparam.lmsi).

send_sri(MSID) ->
    sri(MSID)
```

Partial evaluation of transition clauses gives us Erlang/EFSM edge clauses.

Erlang/EFSM edge clauses

```
idle(slir,MSISDN,LocType,MaxAge,SMSTextType,NetPar,EnforcePSI)
 when EnforcePSI==false,
      hlrlocMethod(MSISDN)==ati,
      is_record(NetPar,netparam) ->
  fsm(NetPar#netparam.mscid,NetPar#netparam.imsi,NetPar#netparam.lmsi),
  fsmTimerr(),
  {next_state,force_update};

idle(slir,MSISDN,LocType,MaxAge,SMSTextType,NetPar,EnforcePSI)
 when EnforcePSI==false,
      hlrlocMethod(MSISDN)==ati,
      not is_record(NetPar,netparam) ->
  sri(MSISDN),
  {next_state,access_netparam}.
```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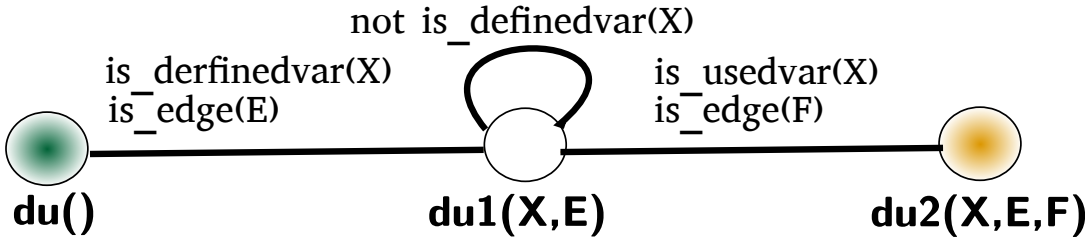
Specifying Test Case Selection

- Typically a tool can generate *huge* numbers of test cases from a model
- Often practical limits on test suite size
  - Complicated environments
  - SUT treated as a black box
- How to generate "best" test suite of bounded size ?

Observers

- **Observation:** Many existing coverage criteria in the litterature
  - A coverage criterion is a set of *requirements* (called coverage items) on test suite
  - Examples: *All locations*, *All edges* and *All Definition-Use pairs*
  - Unclear when and what coverage criteria to use
- **Motivation:**
  - Make it possible to specify *any* coverage criteria
- **Approach:**
  - Specify a coverage criterion by the use of (another) state machine
  - Introduces Erlang/Obs as a specification language for observers

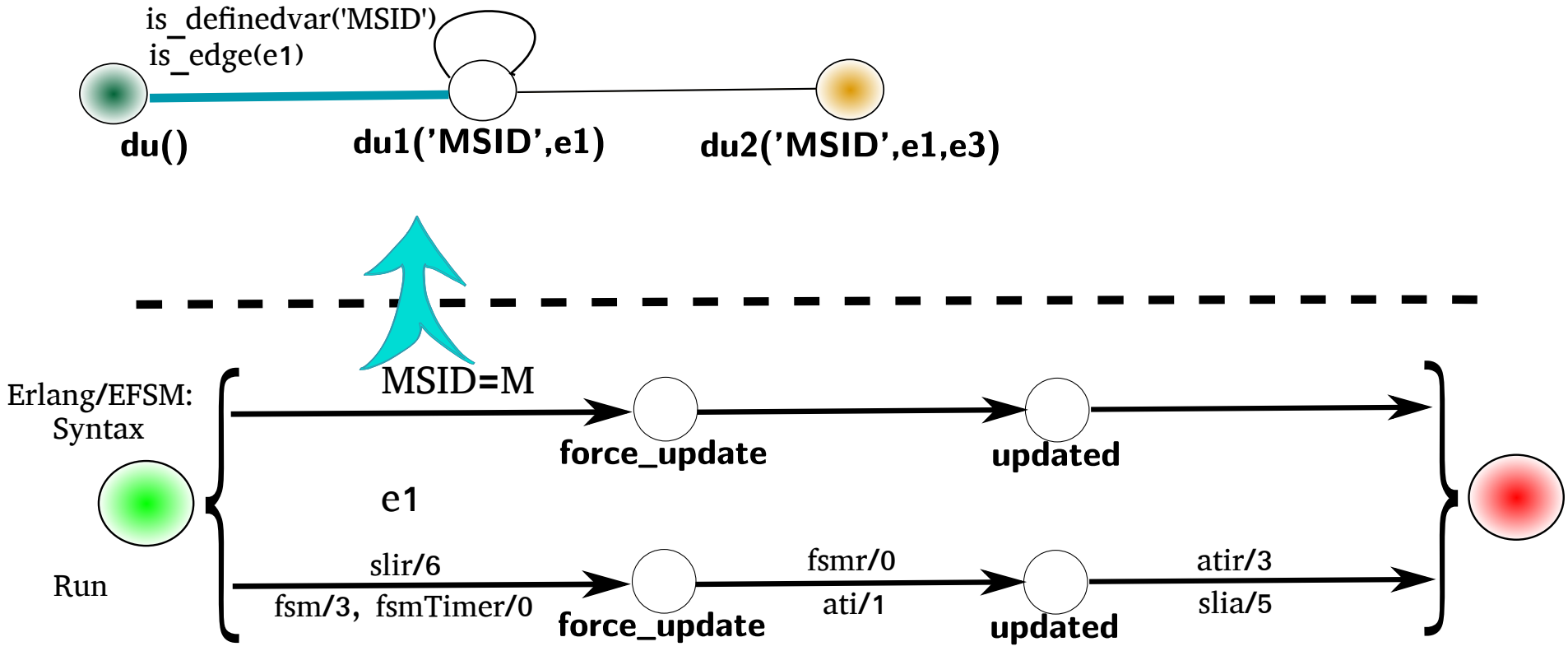
Erlang/Obs Definition-Use




```
du() when is_definedvar(X),is_edge(E) ->
    {next_state,du1(X,E)}.

du1(X,E) when not is_definedvar(X) ->
    {next_state,du1(X,E)};
du1(X,E) when is_usedvar(X),is_edge(F) ->
    {accept_state,du2(X,E,F)}.
```

- is_definedvar(X), is_edge(E) etc. are *observer predicates*
- X and E etc. are variables that are bound by need (compare with Prolog)
- Observer predicates are user definable


is_definedvar('MSID')
is_edge(e1)
du()
du1('MSID',e1)
du2('MSID',e1,e3)
MSID=M
Erlang/EFSM:
Syntax
force_update
updated
e1
Run
slir/6
fsm/3, fsmTimer/0
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fsmr/0
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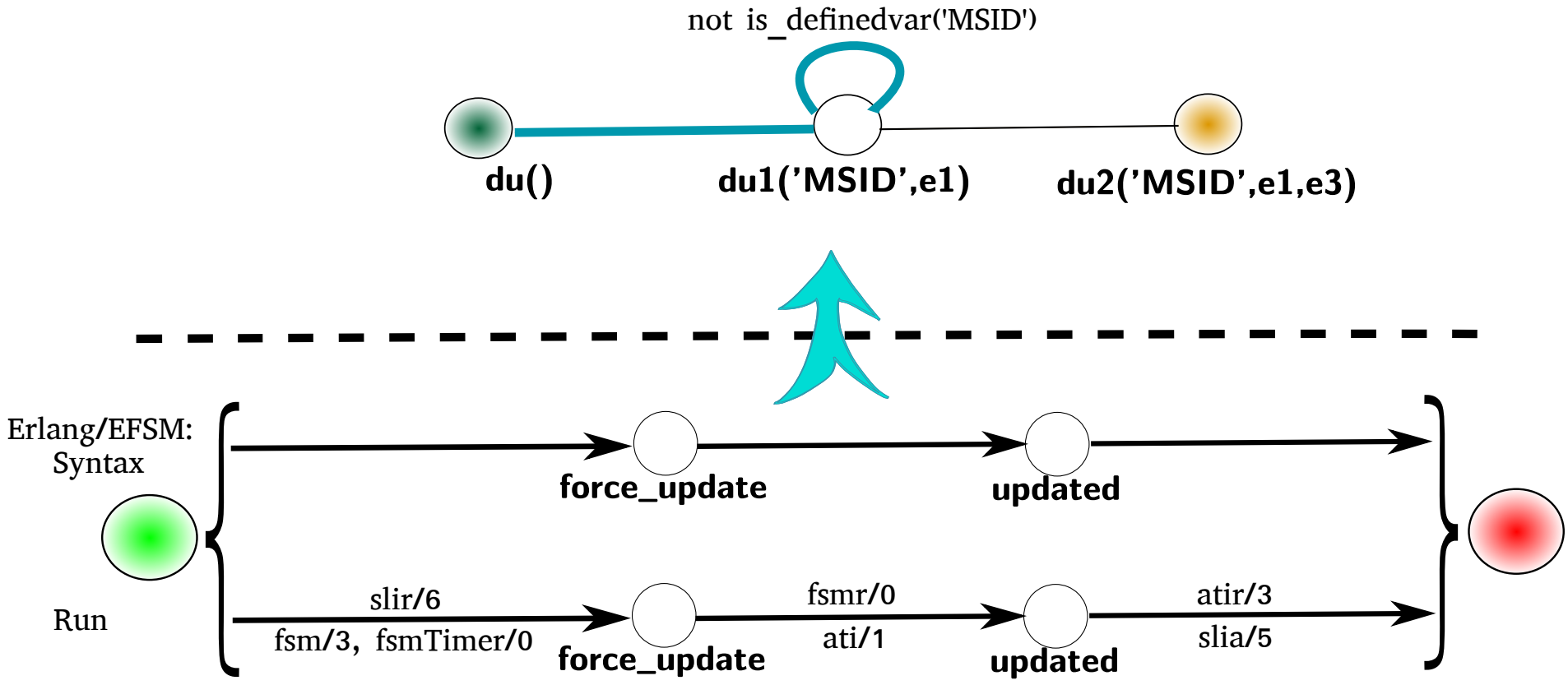
not is_definedvar('MSID')
du()
du1('MSID',e1)
du2('MSID',e1,e3)
Erlang/EFSM:
Syntax
force_update
updated
Run
slir/6
fsm/3, fsmTimer/0
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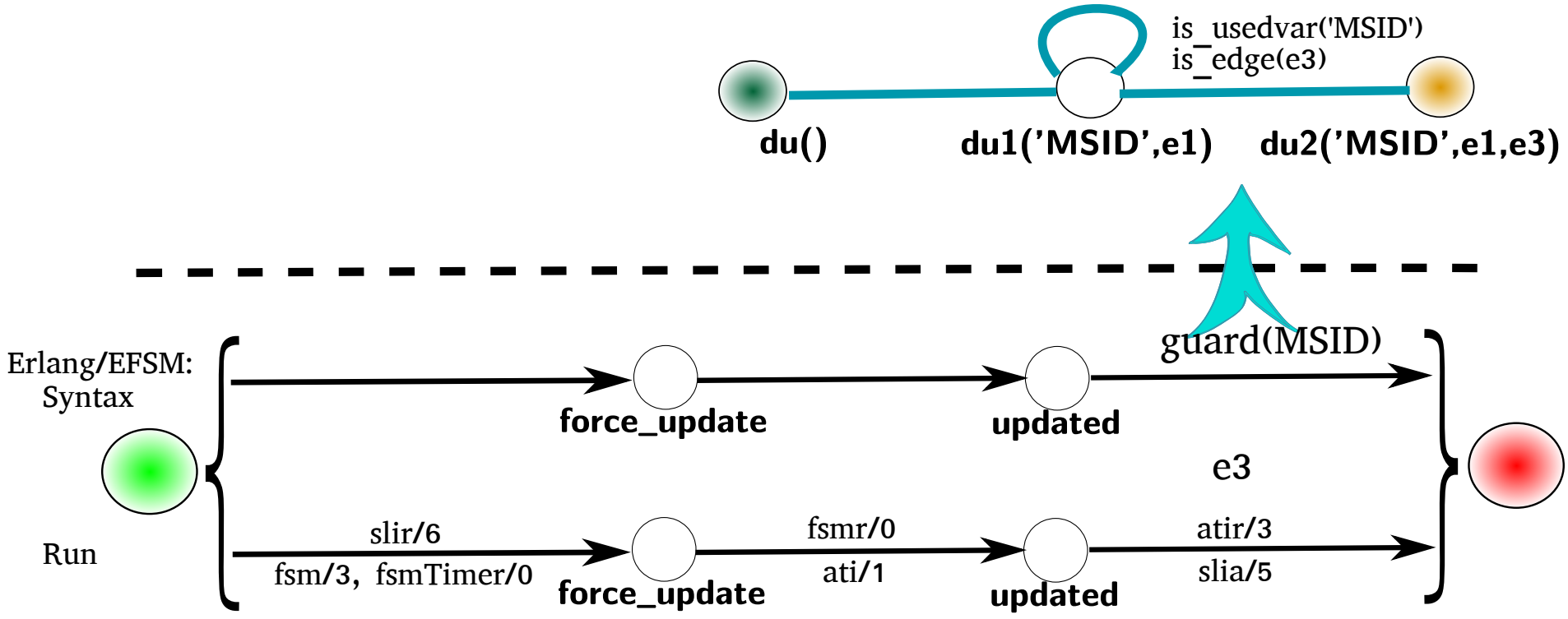
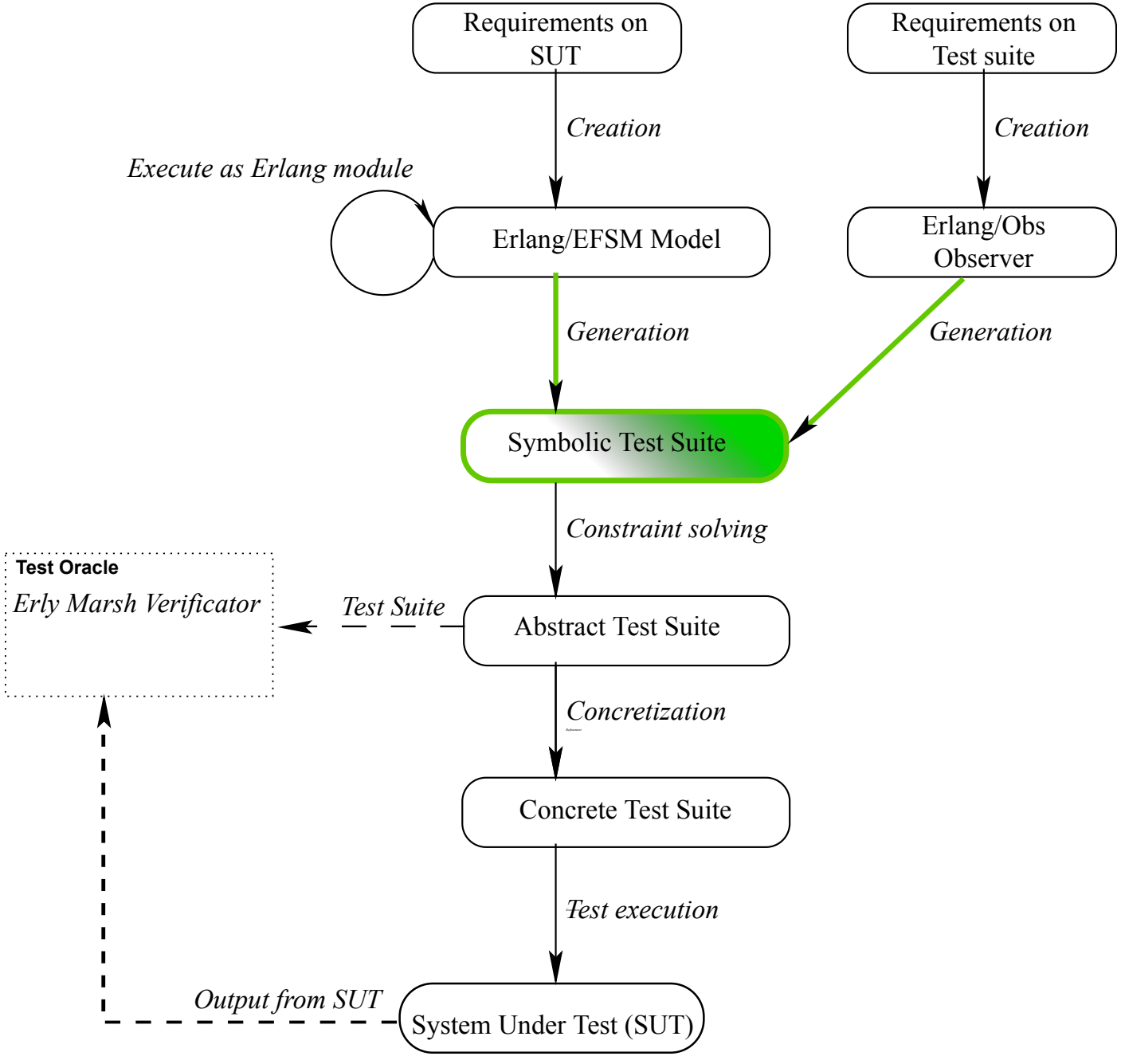

is_usedvar('MSID')
is_edge(e3)
du()
du1('MSID',e1)
du2('MSID',e1,e3)
guard(MSID)
Erlang/EFSM:
Syntax
force_update
updated
e3
Run
slir/6
fsm/3, fsmTimer/0
force_update
fsmr/0
ati/1
updated
atir/3
slia/5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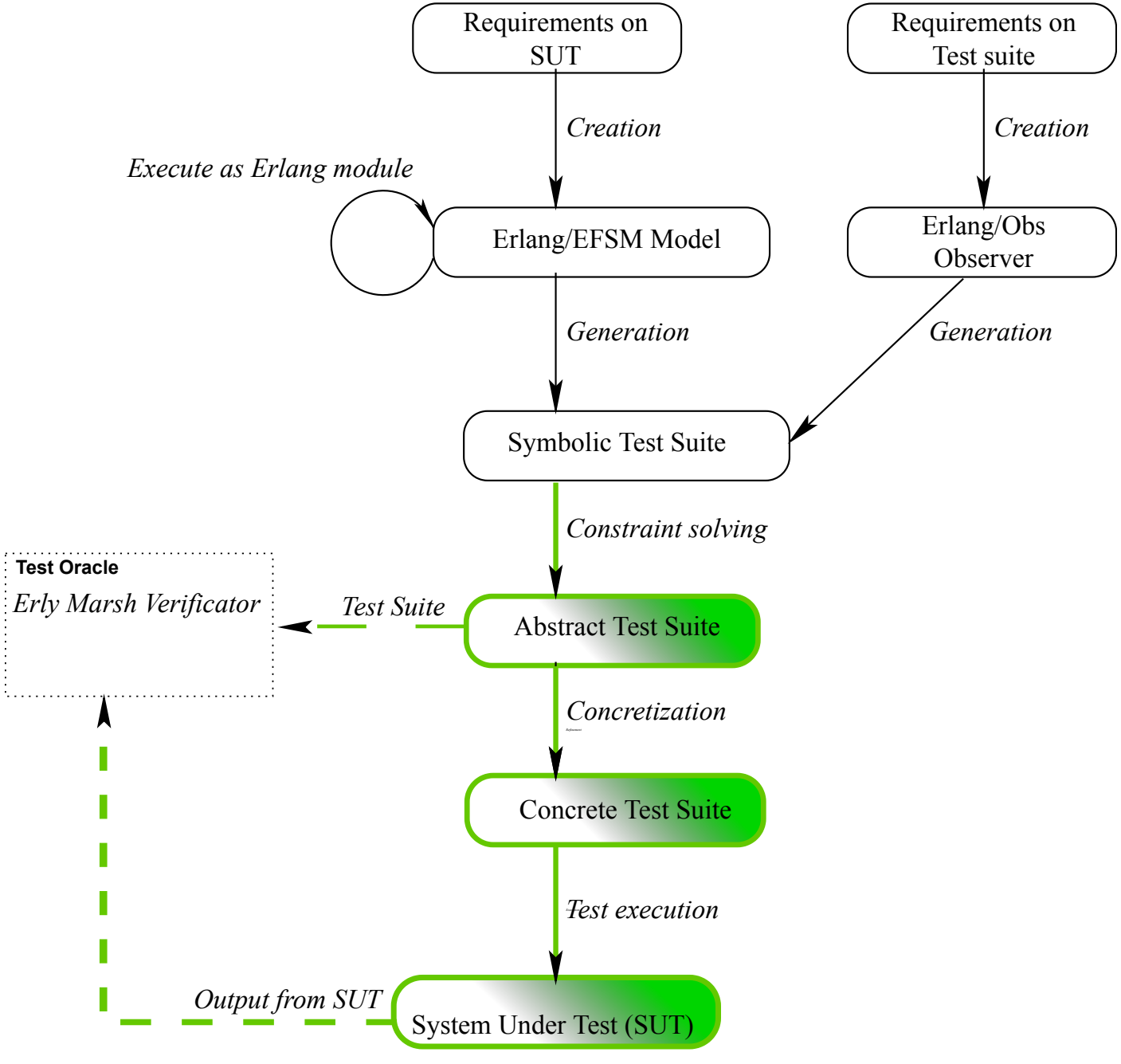
Symbolic Test Suite

- Too many excutions of model $\rightarrow$ Use *symbolic* execution
- Symbolic excutions handles *sets of* executions
- Adapted to handle Erlang/EFSM and Erlang/Obs specifications
- ...skip lots of theoretical stuff ...
- Results in Test Case with symbolic parameters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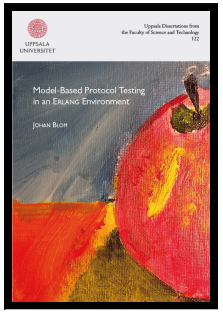
Abstract and Concrete Test Suite

- **Abstract Test Suite**
  - Symbolic parameters can possibly be instantiated in many ways
  - Select each abstract test case from symbolic test case
- **Concrete Test Suite**
  - Concretize generated abstract test suite to format SUT expects
  - SUT specific (handled by Erlang call-back module).
  - In general many concrete possible for each abstract test case

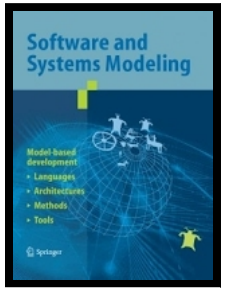
Summary

- Erly Marsh is a Model-Based Testing tool
- Use an abstract model to capture requirements to be tested
  - Introduced Erlang/EFSM for specification of protocols
  - Share syntax and semantics with Erlang
  - Straight forward to transform Erlang/EFSM specification into an executable Erlang module
- Use observers as a tool for flexible specification of coverage criteria
  - Introduced Erlang/Obs, for specification of observers
- Found over 100 faults in that Location server...

References



PhD thesis:
Model-Based Protocol Testing in an Erlang Environment



Software and Systems Modeling:
Special Theme on Model-Based Testing

Github: `http://joh-blo.github.io/erly_marsh/`