Automatic Derivation of Meaningful Experiments for Hybrid Systems

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DExVal Project $\rightarrow$ GMD/CNPq
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Software Validation and Testing

- “Are we building the right thing?”
- Reveal bugs → “good” input values
- Our approach:
  - Verification + Test Data Derivation
  - Hybrid Automata → Constraint Logic Programming (CLP)
  - Situations → expressive logic → constraints
  - Symbolic execution
  - Remaining constraints → input values

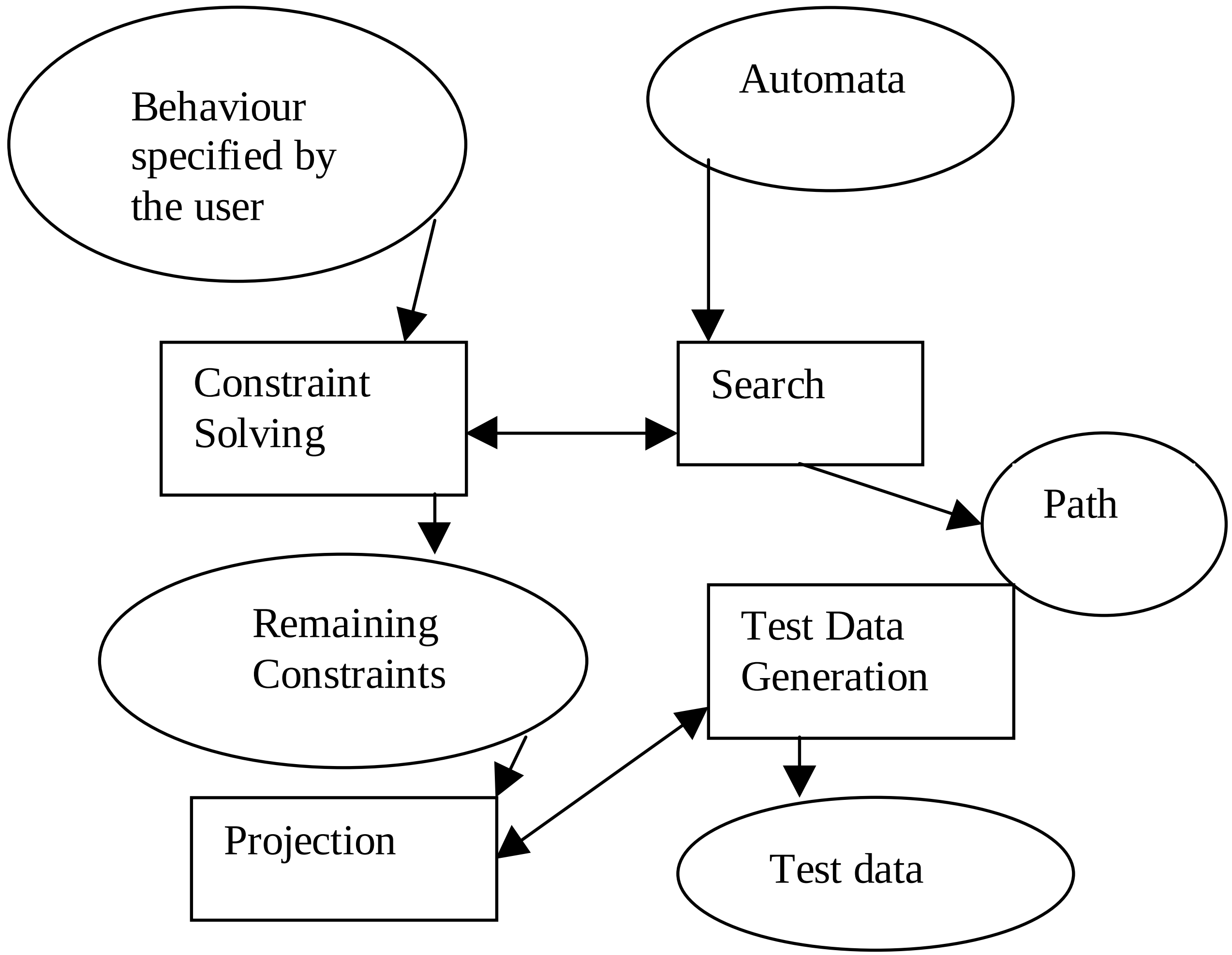
Hybrid Automata

- Variables
- States: name, invariant and iteration
- Transitions: source state, target state, guarded actions and events
- Concurrent timed hybrid automata

Constraint Logic Programming

- Logic Programming (LP): rules, search, backtracking
- Constraint Solving (CS): special-purpose algorithms
- Tight integration: deterministic (CS) and non-deterministic (LP) processes
- Eg.: Accumulated constraints X+Y>5 and Y>0. If X is bound to 6 then CS detects failure

DExVal Architecture



Specification of a Test Situation

- Scenario:
  - instances of classes of automata
  - parameters and synchronization
- User-specified conditions
  - X:t $\rightarrow$ variable X at time t
  - Exist. and universal quantification
  - Modalities: “since”, “until”, “always in the past”, always in the future”, “sometime in the past” and “sometime in the future”

Symbolic Execution

- Representation of automata

  automaton_name(invariant-ST1,OLD_VARS,CONSTRAINTS)

  automaton_name(iteration-ST1,OLD_VARS, NEW_VARS,CONSTRAINTS)

  automaton_name(transition-ST1-ST2, OLD_VARS,NEW_VARS,CONSTRAINTS)

- Execution
  - Automata in parallel
  - Constraints sent to CS during search
  - Output: path and **remaining constraints**
  - Iterative deepening
  - Integration of constraint solvers and dynamic addition of constraints (eg $\forall t\ X{:}t > 20$) $\rightarrow$ Constraint Handling Rules (CHR)

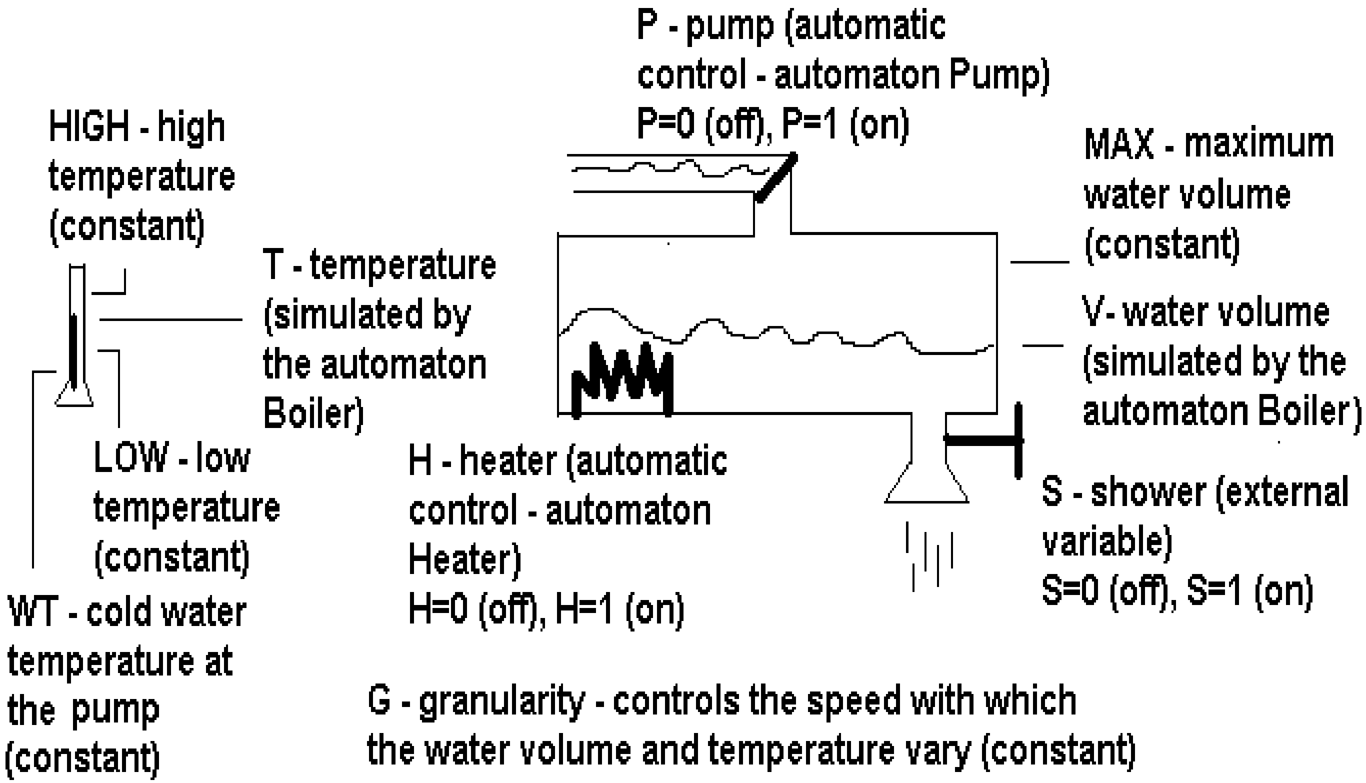
Test Data Derivation Algorithm

- Projection of remaining constraints onto only one variable (repr. an input value) → domain
- Choose value within the domain and assign it to the variable
- Re-evaluate constraints
- Get values for the other variables

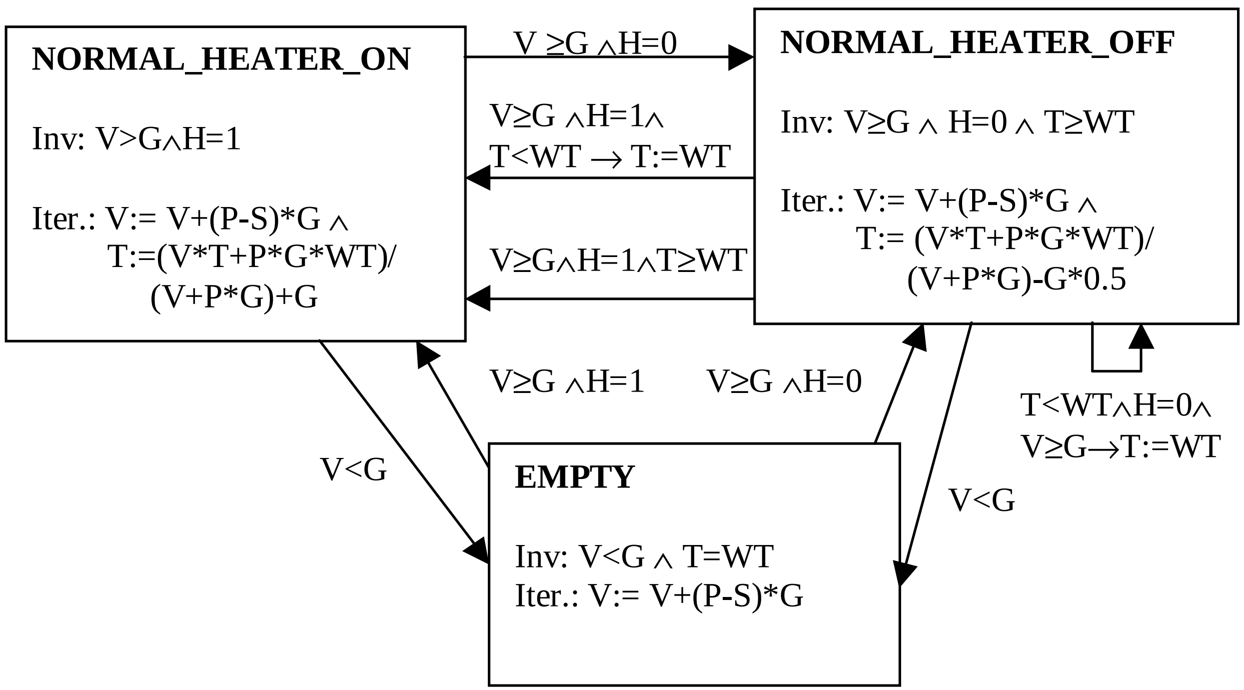
Test Data Derivation Features

- Compatibility with diff. criteria (eg. “mutants” and “coverage of paths”
- Deterministic process
- Expressive language
- Concurrent hybrid automata

Bathroom Boiler Scenario



Automaton Boiler



Example

- Condition: `water_volume:i=10.0`$\wedge$ `temperature:i<100`$\wedge$

  $\forall$`T (heater:T=0)`
- Good values for `temperature:i?`
- Output: 47.181, 73.59 and 99.999

Concluding Remarks

- Importance of CLP
  - Verification and derivation of properties
  - Generation of test cases
- Current work
  - Integration
  - Enhancement of our specialized CS
  - Use of CHR to solve problems with projection (eg. non-linear constraints)