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Beyond Model Checking: Parameters Everywhere

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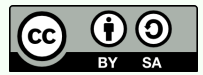
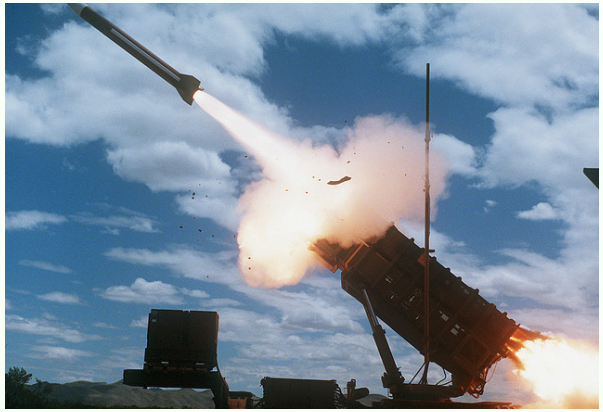


Beyond Model Checking

- ☺ Model checking guarantees the absence of bugs



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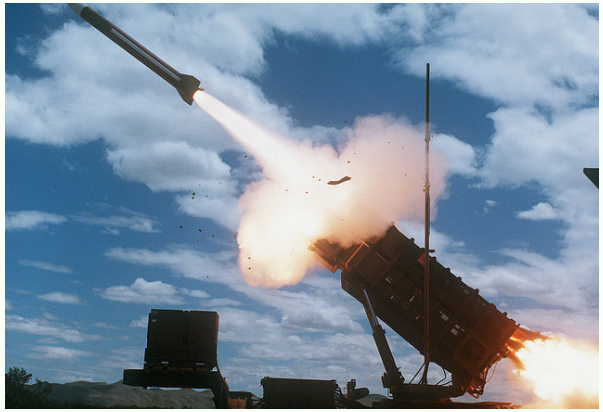

☹ . . . but its use in the industry is rather disappointing

Beyond Model Checking... are Parameters

Two possible reasons for the lack of interest:

- ☹ the binary response to properties satisfaction, which is not informative enough
- ☹ the insufficient abstraction to cater for tuning and scalability of systems

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Challenge

Overcome these limitations by providing parametric formal methods for the verification and automated analysis of systems behaviour

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Instead of "yes" or "no", parameter synthesis answers "yes if..."

- $\rightsquigarrow$ Derivation of correctness conditions

Parameter Synthesis: Interesting but Hard

Interesting applications:

- Infinite systems
- Partially defined systems (timing constants or number of processes not known with certainty)
- Robustness issues (variation of timing delays, clock drifts)

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Mostly undecidable problems (e.g., [Alur et al., 1993, Bozzelli and La Torre, 2009, Jovanović et al., 2013]), with few exceptions:

- Regular model checking
  [Bouajjani et al., 2000, Bouajjani et al., 2008, Bouajjani et al., 2012]
- L/U automata (partially disappointing)
  [Hune et al., 2002, Bozzelli and La Torre, 2009, Jovanović et al., 2013]
- Interrupt automata [Bérard et al., 2012]
- Bounded integer parametric timed automata [Jovanović et al., 2013]

Agenda

1. Exhibit interesting decidable subclasses and write efficient algorithms
2. Design efficient semi-algorithms for undecidable problems
3. Mix different types of parameters together: discrete (processes), timed (delays), probabilistic (uncertainly), costs (energy)

Bibliography

References I

Alur, R., Henzinger, T. A., and Vardi, M. Y. (1993).
Parametric real-time reasoning.
In *STOC*.

Bérard, B., Haddad, S., and Sassolas, M. (2012).
Interrupt timed automata: verification and expressiveness.
Formal Methods in System Design, 40(1):41–87.

Bouajjani, A., Habermehl, P., Holík, L., Touili, T., and Vojnar, T. (2008).
Antichain-based universality and inclusion testing over nondeterministic finite tree automata.
In *CIAA*.

Bouajjani, A., Habermehl, P., Rogalewicz, A., and Vojnar, T. (2012).
Abstract regular (tree) model checking.
STTT, 14(2):167–191.

Bouajjani, A., Jonsson, B., Nilsson, M., and Touili, T. (2000).
Regular model checking.
In *CAV*.

References II

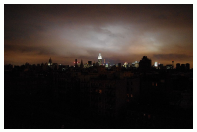
Bozzelli, L. and La Torre, S. (2009).
Decision problems for lower/upper bound parametric timed automata.
Formal Methods in System Design, 35(2):121–151.

Hune, T., Romijn, J., Stoelinga, M., and Vaandrager, F. W. (2002).
Linear parametric model checking of timed automata.
JLAP, 52-53.

Jovanović, A., Lime, D., and Roux, O. H. (2013).
Integer parameter synthesis for timed automata.
In *TACAS*.

Additional explanation

Explanation for the 4 pictures in the beginning



Allusion to the Northeast blackout (USA, 2003)
Computer bug
Consequences: 11 fatalities, huge cost
(Picture actually from the Sandy Hurricane, 2012)

Allusion to any plane crash
(Picture actually from the happy-ending US Airways Flight 1549, 2009)

Allusion to the sinking of the Sleipner A offshore platform (Norway, 1991)
No fatalities
Computer bug: inaccurate finite element analysis modeling
(Picture actually from the Deepwater Horizon Offshore Drilling Platform)

Allusion to the MIM-104 Patriot Missile Failure (Iraq, 1991)
28 fatalities, hundreds of injured
Computer bug: software error (clock drift)
(Picture of an actual MIM-104 Patriot Missile, though not the one of 1991)

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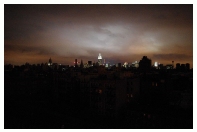

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