Deciding Persistence or Recurrence Membership

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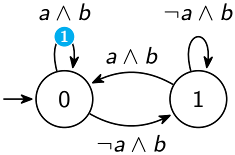
A significant portion of this presentation is inspired by Alexandre Duret-Lutz's contributions to the prcheck paper still on progress.

Context

1. Context
2. Deciding Recurrence via Deterministic Rabin Automata
3. Deciding Persistence via co-Büchi Automata
4. Comparison of both procedures

An ω-automaton $\mathcal{A} = \langle \Sigma, Q, q_0, M, \Delta, \phi \rangle$



Büchi: Inf(1)

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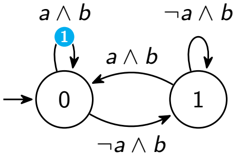
Büchi: Inf(1) co-Büchi: Fin(0)



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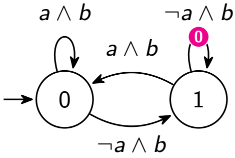
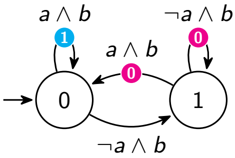
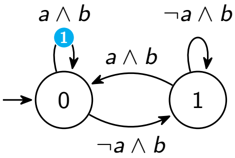


co-Büchi: Fin(0)

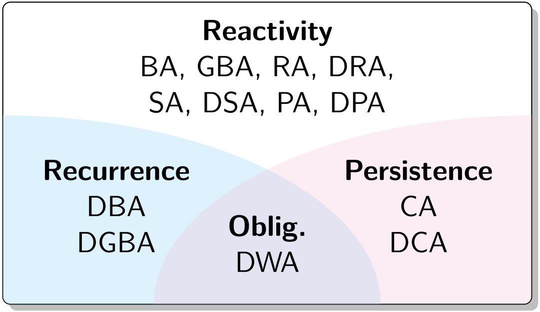


Streett: Fin(0) $\vee$ Inf(1)

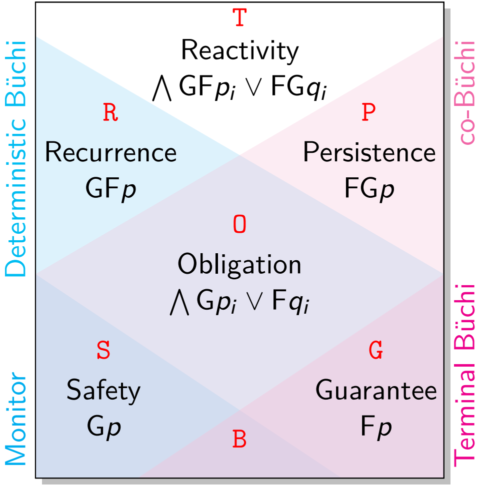


Rabin: Fin(0) $\wedge$ Inf(1)

Expressiveness



Temporal hierarchy of Manna & Pnueli



Manna and Pnueli [MP90]

A hierarchy of temporal properties.

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DBA-realizability

Recurrence class

The recurrence class contains all properties that can be recognized by a DBA.

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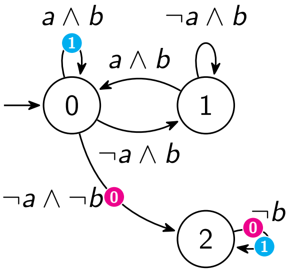
The recurrence class contains all properties that can be recognized by a DBA.

Theorem ([KPB94])

A DRA is DBA-realizable iff it is DBA-type.

Converting a DRA into an equivalent DBA when it exists



Rabin: Fin(0) $\wedge$ Inf(1)

$T_B = \{ \quad \}$

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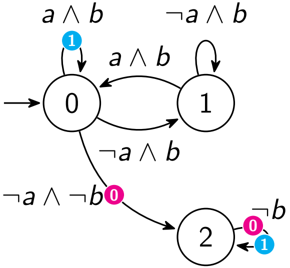

Rabin: Fin(0) $\wedge$ Inf(1)

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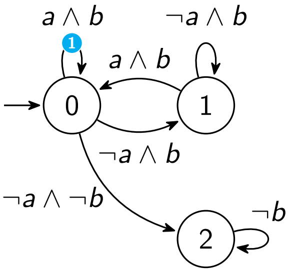
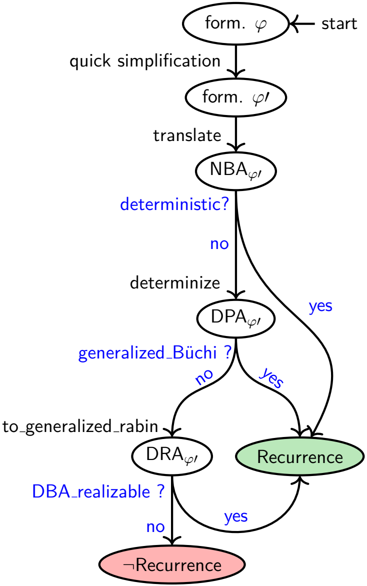


Büchi: Inf(1)

$$T_B = \{(0,0)\}$$

Deciding Recurrence membership of $\varphi = f \vee \neg f$ via DRA



Our contributions

- Quick simplification
- DBA_realizable

Deciding Persistence via co-Büchi Automata

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A co-Büching Toolbox [AÏ7]

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- Based on [BK09, BK11],

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- But, guarantees that $\mathscr{L}(\mathcal{A}_\varphi) \subseteq \mathscr{L}(\mathcal{A}_{NCA})$ and $\mathscr{L}(\mathcal{A}_\varphi) \subseteq \mathscr{L}(\mathcal{A}_{DCA})$

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- $\mathcal{A}_{NCA}$ constructed on top of $\mathcal{A}_\varphi \times \text{subset\_cons}(\mathcal{A}_\varphi)$

A co-Büching Toolbox [AÏ17]

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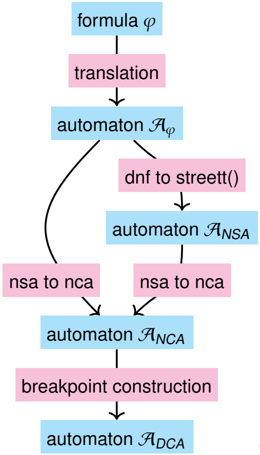
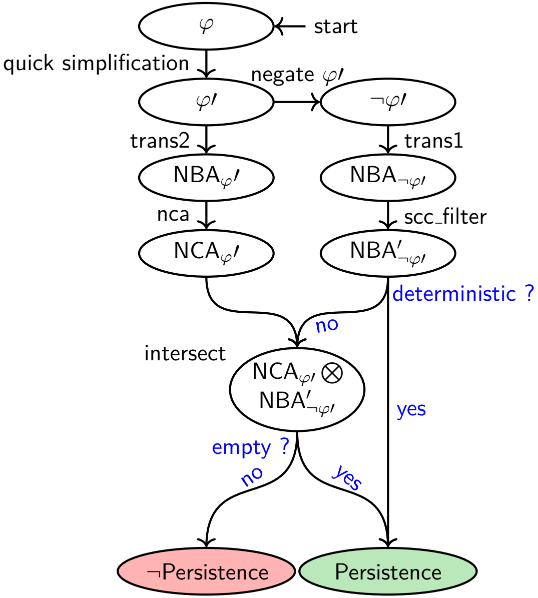


Deciding Persistence membership of $\varphi = f \vee \neg f$ via NCA



Our contributions

- Quick simplification
- Determinism check
- Avoid Aug. subset cons. when possible
- Avoid dead SCCs

Summary: pros and cons

	Method 1 (via CA)	Method 2 (via DRA)
Translations	$\varphi' \rightarrow \text{NBA}_{\varphi'}$ $\neg\varphi' \rightarrow \text{NBA}_{\neg\varphi'}$	$\varphi' \rightarrow \text{NBA}_{\varphi'}$ -
Conversions	$\text{NBA}_{\varphi'} \rightarrow \text{NCA}_{\varphi'}$ -	$\text{DPA}_{\varphi'} \rightarrow \text{DRA}_{\varphi'}$ $\text{DRA}_{\varphi'} \rightarrow \text{DBA}_{\varphi'}$
Determinization	-	$\text{NBA}_{\varphi'} \rightarrow \text{DPA}_{\varphi'}$
Powerset	In $\text{NBA}_{\varphi'} \rightarrow \text{NCA}_{\varphi'}$	-
Acceptance sets	State-based	Transition-based

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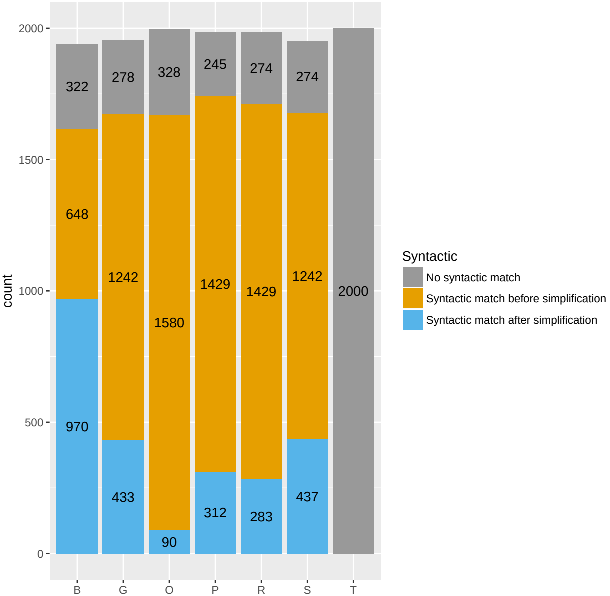
Benchmark's datasets

Two datasets generated using Spot [DLLF+16]

- 13816 random formulas obtained with `randltl` and `ltlfilt`,
- 406 pattern formulas obtained with `genltl` and `ltlfilt`.

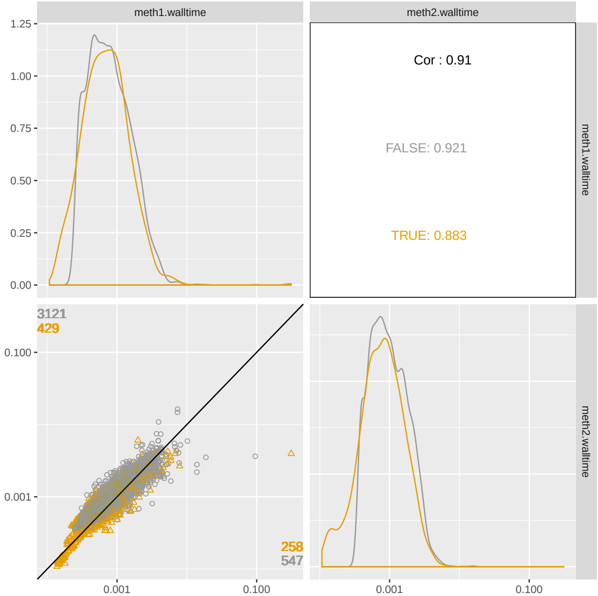
Distribution of random formulas by classes



Random formulas not matched syntactically

- 4746 for persistence,
- 4803 for recurrence.

Deciding persistence on random formulas

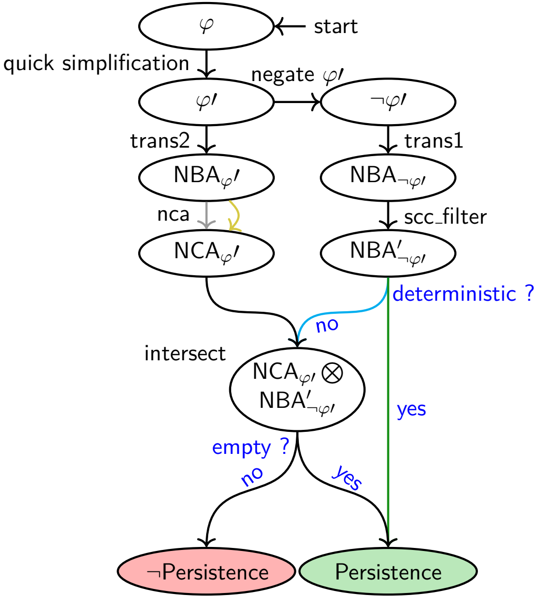


Legend

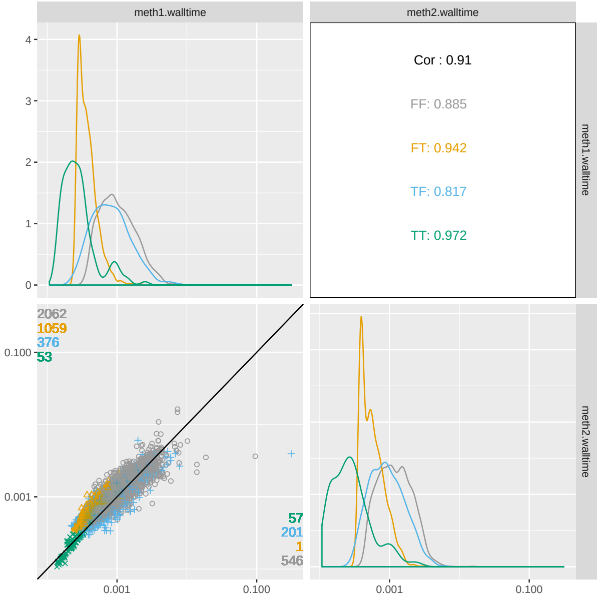
False: not pers.

True: pers.

Processing chains



Highlighting Points



Legend

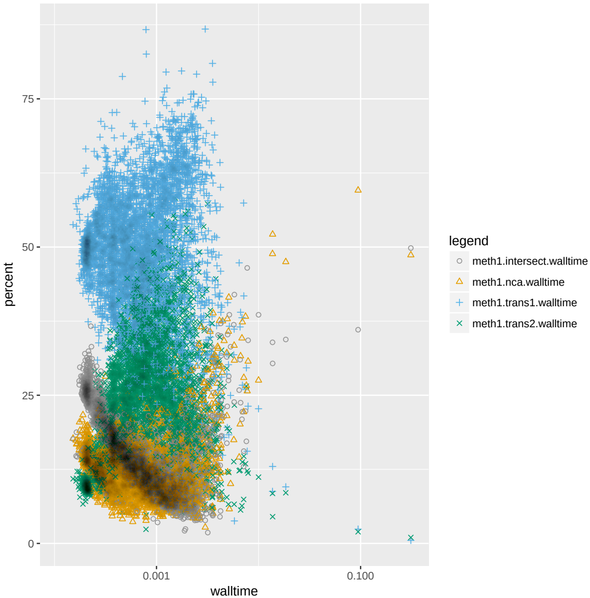
FF: $\varphi\prime$ not pers. & $\mathcal{A}_{\varphi\prime}$ not det.

FT: $\varphi\prime$ not pers. & $\mathcal{A}_{\varphi\prime}$ det.

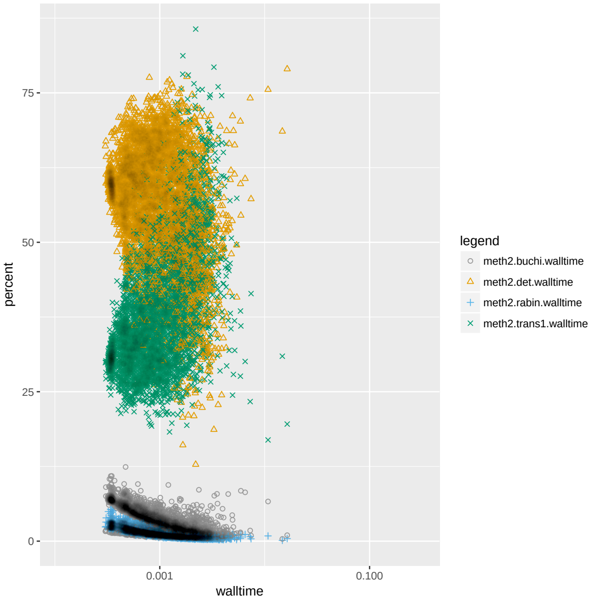
TF: $\varphi\prime$ pers. & $\mathcal{A}_{\neg\varphi\prime}$ not det.

TT: $\varphi\prime$ pers. & $\mathcal{A}_{\neg\varphi\prime}$ det.

Time consumption of method 1



Time consumption of method 2



Conclusion

Our Work

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- Extend method via CA to transition-based acceptance

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Future work

- Extend method via CA to transition-based acceptance
- Benchmark constructions of DBA with both methods,
- Decide Persistence/Recurrence at a syntactical level by rewriting φ.

Bibliography I

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