

Levente Bajczi
https://leventebajczi.com

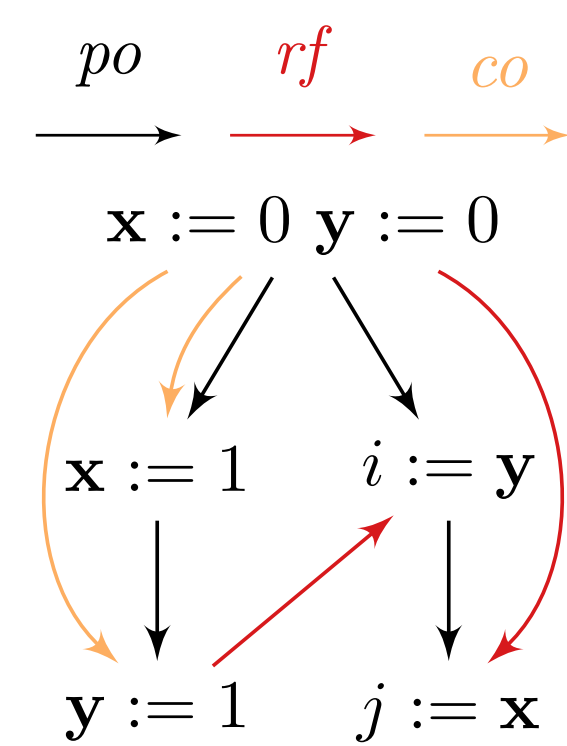
EXAMPLE

x := 0, **y** := 0

x := 1 | *i* := **y**
y := 1 | *j* := **x**

$\neg(i = 1 \wedge j = 0)$

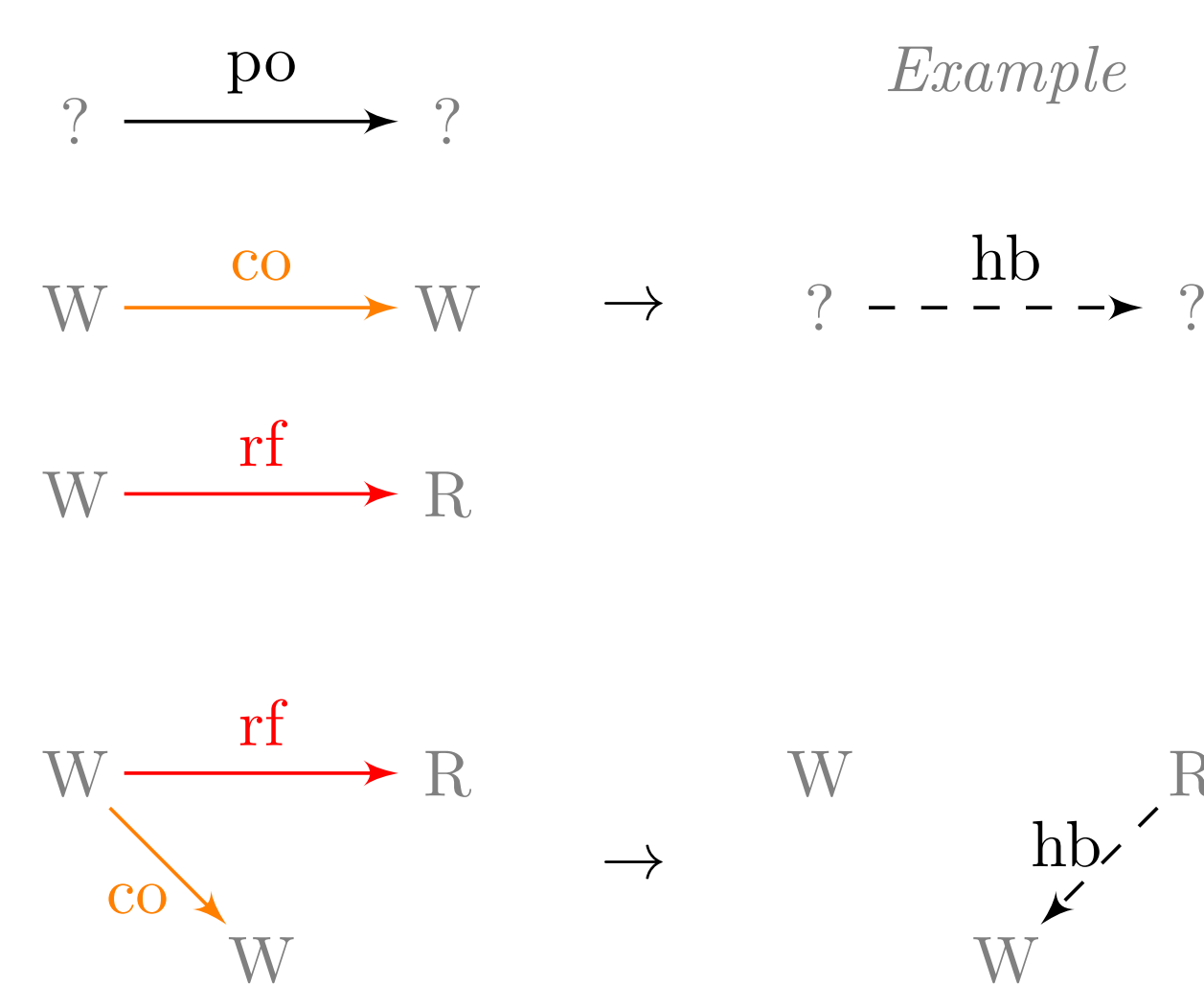
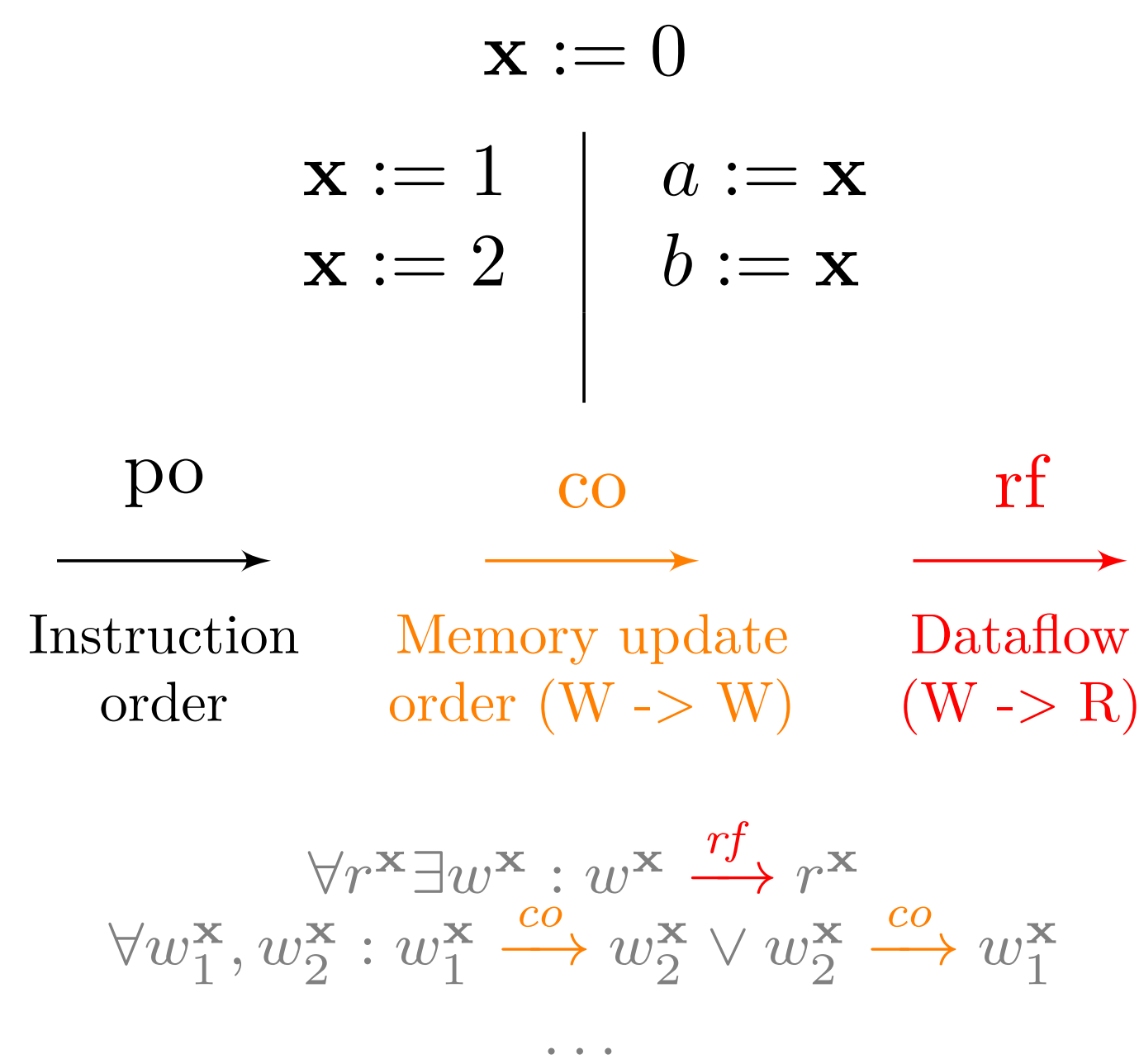
Program with property



CEx. candidate

Bold variables are global, *italicized* variables are local.
The program is safe under SC and TSO but not PSO.

MEMORY MODELS OVERVIEW



Find *co* and *rf* for a given *po* such that *hb* is acyclic.

TOOLS FOR WEAK MEMORY

Exhaustive Enumeration

Generate execution candidates, and check their consistency

Herd7 [2]

(memory model simulator)
Litmus tests CAT
memory model

Stateless Model Checking

Generate increasingly larger, always consistent executions (traces)

GenMC [5], **Nidhugg** [1],

...
(Subset of) C11
Custom library

Bounded Model Checking

Encode constraints of the memory model in the SMT query

Dartagnan [4]

(SV-COMP flavored) C
Subset of CAT

VIOLATION WITNESS EXAMPLE

| Thread 0 | waypoint type | value | line | column |
|----------|---------------|------------------------------------|------|---------------|
| | assume | $\backslash at(\mathbf{x}, 0) = 0$ | 0 | <i>middle</i> |
| | assume | $\backslash at(\mathbf{y}, 0) = 0$ | 0 | <i>end</i> |
| | thread_start | 1, 2 | 1 | 0 |
| Thread 1 | | | | |
| | assume | $\backslash at(\mathbf{x}, 1) = 1$ | 1 | <i>end</i> |
| | assume | $\backslash at(\mathbf{y}, 1) = 1$ | 2 | <i>end</i> |
| Thread 2 | | | | |
| | assume | $i = \backslash at(\mathbf{x}, 1)$ | 1 | <i>end</i> |
| | assume | $j = \backslash at(\mathbf{y}, 1)$ | 2 | <i>end</i> |
| | target | - | 2 | <i>end</i> |

A violation witness, encoding a violation under PSO

CORRECTNESS WITNESS EXAMPLE

| invariant type | value | line | column |
|----------------|--|--------------------|---------------|
| location | $\backslash at(\mathbf{x}, 0) = 0$ | 0 | <i>middle</i> |
| location | $\backslash at(\mathbf{y}, 0) = 0$ | 0 | <i>end</i> |
| location | $\backslash at(\mathbf{x}, 1) = 1$ | 1 (<i>left</i>) | <i>end</i> |
| location | $\backslash at(\mathbf{y}, 1) = 1$ | 2 (<i>left</i>) | <i>end</i> |
| location | $\exists a : a \in \{0, 1\}$ $i = \backslash at(\mathbf{x}, a)$ | 1 (<i>right</i>) | <i>end</i> |
| location | $\exists a, b : a, b \in \{0, 1\}$ $j = \backslash at(\mathbf{y}, a)$ $i = \backslash at(\mathbf{x}, b)$ $b = 1 \implies a = 1$ | 2 (<i>right</i>) | <i>end</i> |
| location | $\neg(i = 1 \wedge j = 0)$ | 2 (<i>right</i>) | <i>end</i> |

A correctness witness, encoding a proof over SC

MAPPING VERDICTS TO WITNESSES

$\backslash at(\mathbf{e}, \mathbf{id})$: Built-in ACSL construct (*abused a bit*)

- referring to the value of the expression **e** in the state at label **id** [3]
- Our *state labels* are integers, and denote ordering of memory events.
- Correctness: *state labels* are **symbolic** integers, and denote ordering of memory events.

FUTURE PLANS

- Implement witness serialization (THETA, CPACHECKER)
- Implement violation witness checking (THETA)
- Implement correctness witness checking (THETA)



REFERENCES

- Agarwal, P., Chatterjee, K., Pathak, S., Pavlogiannis, A., Toman, V.: Stateless Model Checking Under a Reads-Value-From Equivalence. In: Silva, A., Leino, K.R.M. (eds.) Computer Aided Verification. pp. 341–366. Springer International Publishing, Cham (2021)
- Alglave, J., Maranget, L., Tautschnig, M.: Herding Cats: Modelling, Simulation, Testing, and Data Mining for Weak Memory. ACM Trans. Program. Lang. Syst. **36**(2) (jul 2014). <https://doi.org/10.1145/2627752>
- Baudin, P., Cuoq, P., Filliatre, J.C., Marché, C., Monate, B., Moy, Y., Prevosto, V.: ACSL: ANSI/ISO C Specification Language v1.20. Tech. rep., Frama-C (2024)
- Gavrilenco, N., Ponce-de León, H., Furbach, F., Heljanko, K., Meyer, R.: BMC for Weak Memory Models: Relation Analysis for Compact SMT Encodings. In: Dillig, I., Tasiran, S. (eds.) Computer Aided Verification. pp. 355–365. Springer International Publishing, Cham (2019)
- Kokologiannakis, M., Vafeiadis, V.: GenMC: A Model Checker for Weak Memory Models. In: Computer Aided Verification: 33rd International Conference, CAV 2021, Virtual Event, July 20–23, 2021, Proceedings, Part I. p. 427–440. Springer-Verlag, Berlin, Heidelberg (2021). https://doi.org/10.1007/978-3-030-81685-8_20

REPORT

