



Salsa: Beyond Model Checking*

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Salsa web site: www.reactive-systems.com/salsa

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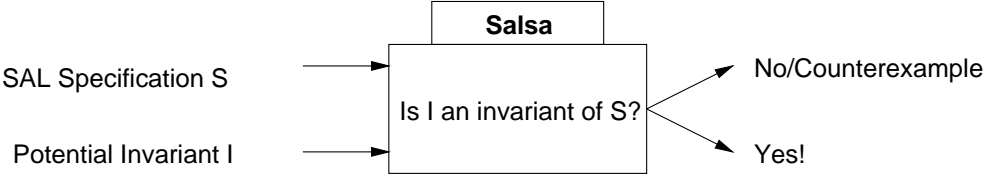
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What does Salsa do?



Why does Salsa work?



3

Goals:

- As easy to use as a model checker
- Scales like a theorem prover

Practical usage of Salsa:

- NRL: Cryptographic Device (CD) [27]
- Reactive-Systems Inc/Ford: Simulink/Stateflow specifications
- SUNY Stony Brook: CAN bus protocol

The Verification Problem

Given the following:

- A system description
- A set of environmental assumptions
- A set of required properties (one-state or two-state)

Verification is the process of:

- Extracting **models** from the system description.
Sufficient to establish the properties of interest.
- Applying a verification tool to the model to verify/refute properties.

Very likely that a property is not provable (or wrong).

A tool should provide **diagnostic information**.

How can a tool help?



5

1. **Diagnostic information**
Counterexamples.
2. **Comprehensible diagnostics**
In the “language” of the original description.
3. **Compact diagnostics**
4. **No misdiagnoses**
Very hard to achieve in practice.

Conventional Wisdom

Model Checking

- Automatic, easy to use, counterexamples.

Theorem Proving

- Too general, too expensive, hard to use,...

But the reality is...

Attributes of Model Checking:

1. Completeness
2. Termination
3. Diagnostic information
4. **State explosion problem**

Attributes of Theorem Proving:

1. **Incompleteness**
Auxiliary lemmas.
2. **Not guaranteed to terminate**
Decision procedures.
3. Diagnostic information?
Make it comprehensible to layfolk.
4. Infinite State

Combines Model Checking and Theorem Proving

Strengths:

- Reliance on *decision procedures*
- Combination of decision procedures
- Guaranteed termination
- Counterexamples
- Push-button automation

Weaknesses:

- Counterexample not a trace
- Incomplete – counterexamples must be validated

Salsa vs. Model Checking



10

Salsa...

- Can handle specs too large for model checkers (single pre-image vs fixed point computation)
- **More automatic!** (no manual abstractions)
- Counterexamples

- CCC of the SCR Toolset (tautology checking vs UC) [22,23,24]
- TAME/PVS [3,30]
- InVeSt [5,6]
- Graf's tools [21,32]
- STeP [11]
- SPIN and SMV on software specs [2,9,16,22]

Notes: – First four designed for ease-of use.
– First three provide counterexamples.
– STeP requires user interaction.
– Model checkers require the application of abstraction [2,7,8,9,10,27]; they may not always scale (i.e., neither verify/refute) [27].

Empirical Results



Specification	Number of			Time (in S) to Check Disj		Number of Failed VCs	
	VCs	BDD Vars	Constrs	SCR Tool	Salsa	SCR Tool	Salsa

Specifications containing mostly booleans and enumerated types

safety-injection	13	16	3	0.5	0.2	0	0
bomb-release-1	12	34	9	0.4	0.2	0	0
a7-modes	6171	158	3	145.9	68.9	110	152

Specifications containing mostly numerical variables

autopilot	29	50	27	1.5	1.0	0	0
home-heating	98	112	55	∞_t	4.8	n.a.	0
cruise-control	123	114	75	21.0	3.6	6	3
navy-1	252	115	78	322.8	59.7	0	0
navy	397	147	102	390.1	198.2	0	0
bomb-release-2	339	319	230	∞_t	246.0	n.a.	11
wcp	58	611	104	-	77.4	-	0

Empirical Results (con't)



13

Spec.	Props. or #	Time (in seconds)				Props. True?	Aux. Lemmas?
		Salsa	SPIN	SMV	TAME		
sis	4	0.8	36.0	155.0	68	Yes	Yes
bre11	2	1.3	∞_t	∞_t	30	Yes	No
autop	2	1.5	∞_t	∞_t	82	Yes	No
navy	7	396.0	∞_t	-	874	Yes	Yes
wcp	# 303	295.4	∞_t	-	∞_t	No	No
	# 304	923.3*	∞_t	-	19	No	No
	# 305	2.4	∞_t	-	8	No	No

- Consistency checking goals achieved
 - Faster
 - Handles integers
 - Able to handle bigger specs
- Bonus: also handles user properties.
 - Handles specs too big for model checkers
 - Seems to be “in the ball park” with PVS
- Weaknesses (w.r.t model checkers):
 - Incompleteness
 - Two-state counterexamples rather than trace from start state.

Stages of Acceptance of Innovation



15

An innovation has three stages of acceptance: First, it is dismissed as rubbish, then it's merely nonviable, and finally it's obvious and trivial – “What we've done all along.”

John Vlissides.