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SMT-COMP 2014

David Cok
David Deharbe
Tjark Weber

The Numbers

- 13 Teams participated
- 18 (+2 historical) Solvers entered the main track
  4(+1) in the incremental track
- 32 logics (2 logics with no eligible benchmarks)
  25 logics had participation from more than one team
- 67426 main track competition benchmarks (out of 137648 total)
- 339714 job-pairs executed (+ some repeats)
- ~ 1 week x 147 nodes of compute time
- 1 new sibling competition (SL-COMP) organized

Record numbers!

StarExec

- Some initial startup problems, partly bugs, partly user error, but otherwise

StarExec worked great

- Required porting tools to StarExec – thanks Tjark and David
- Thanks to Aaron Stump for prompt help when problems or questions arose
- Continuing to run major jobs with long (10 hour) timeouts to resolve sat/unsat status of unknown benchmarks

Solver participation – 2014

Solver	Affiliation	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
		12	12	9	13	12	10	11	11	10	18
NEW											3
Abziz…	Cairo U.							X	X		2
Boolector	JKU				X	X		X	X	X	3
CVC/CVCLite/CVC3	NYU	X	X	X	X	X	X	X	X		X
CVC4	NYU						X	X	X	X	X
MathSat-HeavyBV	Trento								X		
MathSAT 3,4,5	FBK	X	X	X	X	X	X	X	X	X	
SMTInterpol	U. Freiburg							X	X	X	X
SONOLAR	U. Bremen						X	X	X	X	X
STP, simplifyingSTP, STP2	Stanford, MIT		X			x	X	X	X		X
4Simp	U. Melbourne								X		X
Tiffany de Wintermonte	U. Melbourne								X		
opensmt	U. Lugano				X	X	X	X		X	X
veriT	UFRN					X	X	X		X	X
Z3	MSR			X	X			X		X	
AProVE NIA	RWTH Aachen						X	X			X
MiniSMT	U. Innsbruck						X			X	
test_pmathsat	FBK-IRST						X				
barcelogic	UPC	X	X	X	X	X					
beaver	UC Berkeley				X	X					
clsat	Washington U.				X	X					
Sateen	U. Col.-Boulder	X	X	X	X	X					
Spear				X	X						
sword	U. Bremen				X	X					
Yices	SRI	X	X	X	X	X					X
Alt-Ergo	CNRS				X						
ArgoLib				X							
Fx7				X							
Ario		X	X								
ExtSat			X								
HTP		X	X								
Jat			X								
NuSMV			X								
Sammy		X									
SBT		X									
Simplics		X									
SVC		X									

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Benchmarks & Logics

- Many new benchmarks added
  - 137648 main track benchmarks in 34 divisions
    but 35202 are easy and 35020 are unknown,
    leaving 67426 for competition
  - 9925 benchmarks for incremental track in 8 divisions
- Thanks to many contributors
- Thanks to Morgan Deters, Clark Barrett for curation and uploading
  - Checked and reclassified the benchmarks,
    resulting in the expansion to 34 divisions

Incremental track

- *Sorry, data not yet reduced…*
    - *But it will be*

Parallel vs. Sequential

- Emphasized sequential timing since we weren’t sure that solvers were implemented or tuned for parallel solving.
- This is question for future competition design.

Teams & Solvers

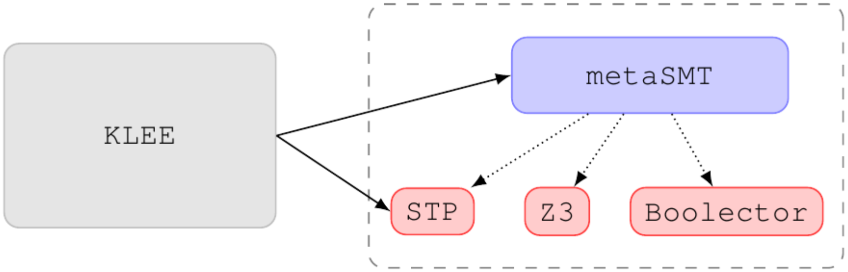
Some first-time participants:

- Hristina Palikareva, Cristian Cadar:
  Kleaver-STP, Kleaver-portfolio (QF_ABV)
- Tung Vu Xuan:
  raSAT (QF_NRA)
- Mate Soos:
  STP-Crypto-MiniSat4 (QF_BV)
  second place in QF_BV

Teams & Solvers

Kleaver

The constraint solver of the symbolic execution engine KLEE:



High-Level Optimizations

- Mathematical simplifications
- Expression canonicalization
- Grouping constraints into independent subsets
- Cache, which exploits subset/superset relations among constraint sets to determine satisfiability of subsequent queries

Teams & Solvers

Some relatively new participants or returning after a few years:

- M. A. Abziz:
  two portfolio solvers (QF_BV)
- Carsten Fuhs:
  AProVE (QF_NIA)

Teams & Solvers

Other regulars in single divisions:

- T. Hansen:
  4Simp (QF_BV)
- Antti Hyvarinen:
  OpenSMT2 (QF_UF)
- Florian Lapschies:
  SONOLAR (QF_BV, QF_ABV)

OpenSMT2

- OpenSMT is a GPL-licensed SMT solver
- The development is coordinated at the University of Lugano in Switzerland
- Version 2 has been under development since summer 2012
  - Native support for the SMTLIB2 standard
  - Separation of the abstract term dag from the theory related representations (such as EUF terms)
  - Compact representation and efficient memory management for the data types including Enodes
  - Currently support for QF_UF (but more is to come)

We are looking for a person interested in doing a PhD on a project related to parallelized SMT solving!

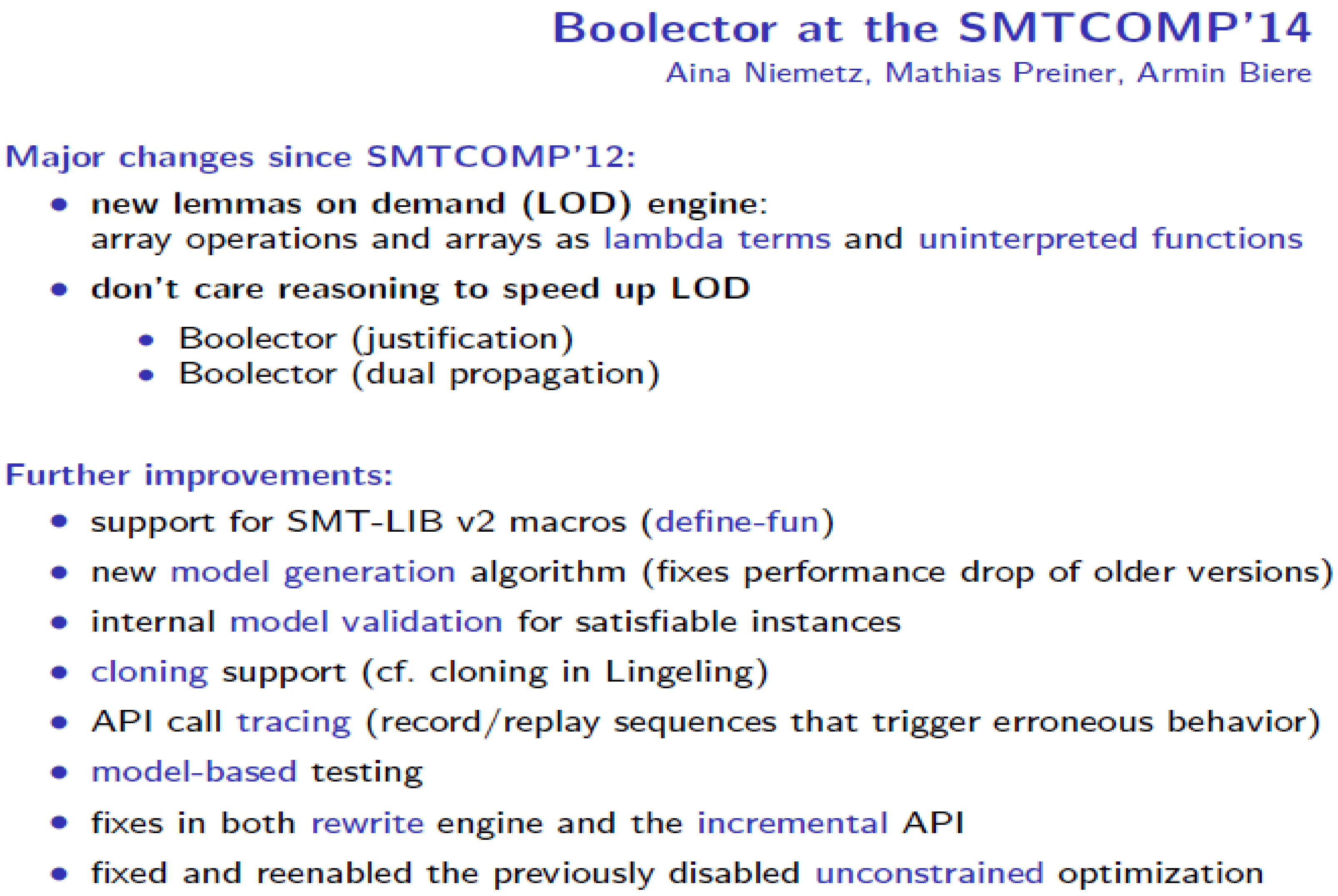
Teams & Solvers

Other regulars in single divisions:

- A. Biere, et al.: Boolector (QF_BV)
  winner QF_BV

  Boolector (2 variations) (QF_ABV)
  winner QF_ABV

Teams & Solvers



Boolector at the SMTCOMP'14

Aina Niemetz, Mathias Preiner, Armin Biere

Major changes since SMTCOMP'12:

- new lemmas on demand (LOD) engine:
  array operations and arrays as lambda terms and uninterpreted functions
- don't care reasoning to speed up LOD
  - Boolector (justification)
  - Boolector (dual propagation)

Further improvements:

- support for SMT-LIB v2 macros (define-fun)
- new model generation algorithm (fixes performance drop of older versions)
- internal model validation for satisfiable instances
- cloning support (cf. cloning in Lingeling)
- API call tracing (record/replay sequences that trigger erroneous behavior)
- model-based testing
- fixes in both rewrite engine and the incremental API
- fixed and reenabled the previously disabled unconstrained optimization

Teams & Solvers

Entrants in many divisions:

- Clark Barrett, Morgan Deters: (all 32 divisions)
  CVC4 – *winner in 14 divisions*
  CVC3 – *winner in 3 divisions*

- Pascal Fontaine, David Deharbe: (17 divisions)
  veriT – *winner in UFLRA*

- Bruno Dutertre: (15 divisions)
  Yices2 – *winner in 10 divisions*
  (back after a few years' absence)

- Jochen Hoenicke, Jürgen Christ: (8 divisions)
  SMTInterpol – *winner in QF_LIA*

CVC4 (NYU and U Iowa)

Clark Barrett (NYU) Cesare Tinelli (U Iowa)

Theories

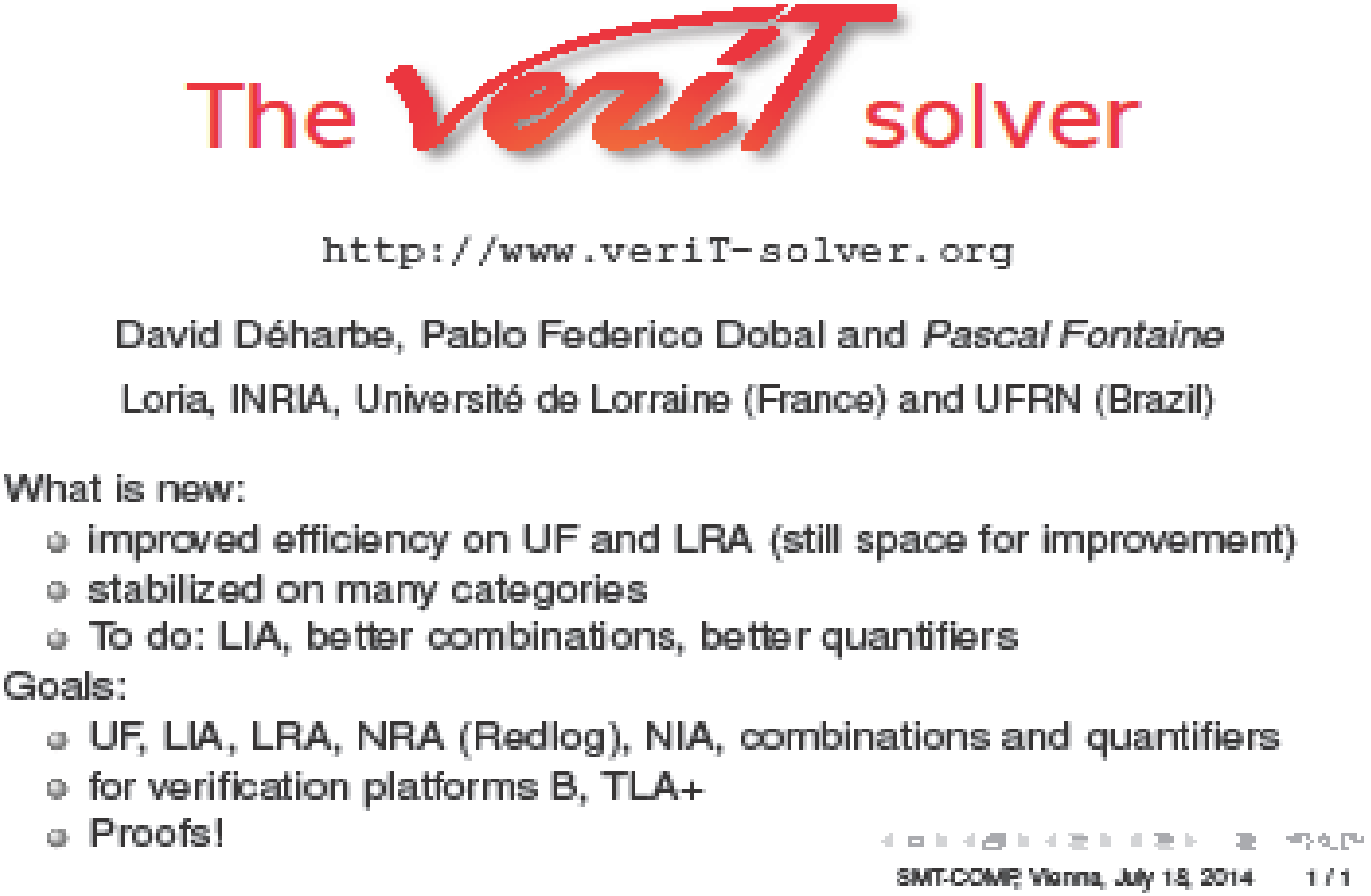
- Arithmetic, Arrays, Bit-vectors, Inductive Data Types, Quantifiers, Sets, Strings, Uninterpreted Functions

Features

- Models, Proofs, Open-Source, BSD License, Portfolio mode, Variety of API's

Performance in SMT-COMP (all divisions, after bug-fix)

- Top solver in 9 divisions
  (AUFLIA, AUFNIRA, LRA, QF_AUFBV, QF_LIA, QF_LRA, QF_UFNIA, UF, UFLIA)
- Overall score (all divisions): 65.56 (Z3: 73.97)
- Excluding non-linear: 55.57 (Z3: 54.82)



The veriT solver

http://www.veriT-solver.org

David Déharbe, Pablo Federico Dobal and *Pascal Fontaine*

Loria, INRIA, Université de Lorraine (France) and UFRN (Brazil)

What is new:

- improved efficiency on UF and LRA (still space for improvement)
- stabilized on many categories
- To do: LIA, better combinations, better quantifiers

Goals:

- UF, LIA, LRA, NRA (Redlog), NIA, combinations and quantifiers
- for verification platforms B, TLA+
- Proofs!

SMT-COMP, Vienna, July 18, 2014   1 / 1

Further Thoughts

- Solvers:
  - First-time entrants had some trouble with system configurations – getting a static build of a tool and getting it to work on StarExec
  - Two entrants dropped out after expressing initial intention
- Benchmarks:
  - Still need more benchmarks; some divisions have relatively few
- Competition:
  - StarExec allowed us to run all eligible benchmarks
  - Continuing to run jobs to resolve unknown benchmarks
  - Revise scoring – more emphasis on timing?
  - Parallel or sequential?
  - Better support needed for incremental benchmarks
  - Separate measure of performance on quick jobs?
- Teams:
  - *Congratulations on your accomplishments*
  - *Thanks for your participation*

SL-COMP'14

Competition of solvers for Separation Logic

Input Theory

Separation Logic *[O'Hearn,Reynolds et al. CSL'01, LICS'02]*

fragment of

Symbolic Heaps with Recursive Definitions

$\Phi ::= \Pi \wedge \Sigma$

$\Pi ::= X=Y \mid X \neq Y \mid \Pi \wedge \Pi$

$\Sigma ::= \mathrm{emp} \mid X \mapsto \{(f_0,Y_0),\dots\} \mid \Sigma \star \Sigma \mid P(Y_0,\dots)$

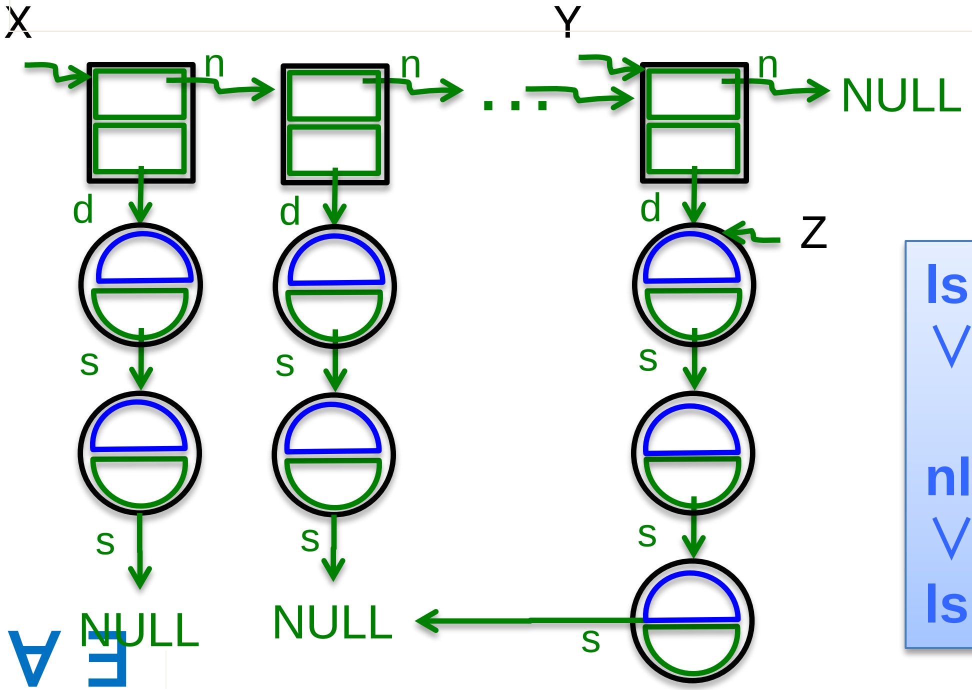
$P(E,\dots) \triangleq \exists Z_0.\ \Pi_0 \wedge \Sigma_0 \ \vee \ \dots \ \vee \exists Z_k.\ \Pi_k \wedge \Sigma_k$

Input Theory

Separation Logic *[O'Hearn,Reynolds et al. CSL'01, LICS'02]*

fragment of

Symbolic Heaps with Recursive Definitions



$X \neq Y \wedge Z \neq \mathrm{NULL} \wedge$
$\mathbf{nll}(X,Y,\mathrm{NULL}) \star$
$Y \mapsto \{(n,\mathrm{NULL}),(d,Z)\} \star$
$\mathbf{ls}(Z,\mathrm{NULL})$

$\mathbf{ls}(E,F) \triangleq E=F \wedge \mathrm{emp}$
$\vee\ \exists U.\ E \neq F \wedge E \mapsto \{(s,U)\} \star \mathbf{ls}(U,F)$

$\mathbf{nll}(E,F,H) \triangleq E=F \wedge \mathrm{emp}$
$\vee\ \exists U,V.\ E \neq F \wedge E \mapsto \{(n,U),(d,V)\} \star \mathbf{ls}(V,H)$

$\star\ \mathbf{nll}(U,F))$

Benchmarks

- Problems: **678**
  - Checking satisfiability 25%
  - Checking entailment validity 75%
- Kind of recursive definitions (division):
  - acyclic singly linked lists (ls) sll0a 59%
  - fixed (nll, dll, skl, …) FDB 6%
  - user-defined UDB 35%
- Origin:
  - crafted 41%
  - random 59%

Competition Rules

- Input format in SMTLIBv2
  - theory QF_S
  - semantics discussed in smtcomp14-sl@googlegroups
  - benchmarks available in github project smtcomp14-sl
- Use of pre-processors for some solvers
- No scrambling of benchmark problems
- Solvers running on **Star-Exec**
- Same score computation as in SMT-COMP’14

Solvers

- **Asterix** *(TUM and MPI, Germany and UCL, UK)*
  - J. Navarro Perez and A. Rybalchenko
- **Cyclist-SL** *(UCL, UK)*
  - J. Brotherston, N. Gorogiannis, and R. L. Petersen
- **SLEEK** *(NUS, Singapore)*
  - Q.L. Le and W.N. Chin
- **SLIDE** *(Verimag, France and VeriFIT, Czech Rep.)*
  - A. Rogalewicz, R. Iosif, and T. Vojnar
- **SLSAT** *(UCL, UK)*
  - J. Brotherston, C. Fuhs, N. Gorogiannis, and J. Navarro Perez
- **SPEN** *(LIAFA, France and VeriFIT, Czech Rep.)*
  - C. Enea, O. Lengal, M. Sighireanu, and T. Vojnar

Results

	Sll0a(sat)	Sll0a(=>)	FDB(=>)	UDB(sat)	UDB(=>)
Asterix	1	1	--	--	--
Cyclist-SL	--	4	2	--	1
SLEEK	3	3	3	1	3
SLIDE	--	--	--	--	2
SLSAT	4	--	--	2	--
SPEN	2	2	1	--	--

http://smtcomp.sourceforge.net/2014/results-SLCOMP2.shtml

Future Work

- Re-defining the SL theory in SMTLIBv2
- Including more benchmarks
  - in existing divisions
  - more divisions, e.g., SL + AI
  - from program analysis and verification tools
- Other problems
  - sat witness
  - (bi-)abduction

Thanks

- David Cok
- Clark Barrett and Cesare Tinelli
- Solver providers: Nikos Gorogiannis, Ondrej Lengal, Le Quang Loc, Juan Navarro Perez, Chin Wei Ngan, Adam Rogalewicz, Radu Iosif, Andrey Rybalchenko, Tomas Vojnar, Constantin Enea.
- Group list support: Josh Berdine, Thomas Wies, Christoph Haase.