

# Satisfiability Modulo Theories Competition SMT-COMP 2005

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# Satisfiability Modulo Theories (SMT)

- Propositional SAT very useful for verification.
- SMT extends SAT with background theories.
- SAT:  $p \wedge q \rightarrow r$
- SMT:  $x = a \wedge y = b \rightarrow f(x, y) = f(a, b)$
- Usefulness for verification due to practical theories:
  - ▶ equality and uninterpreted functions (EUF)
  - ▶ arithmetic
  - ▶ arrays
  - ▶ datatypes (e.g., lists)

# Satisfiability Modulo Theories Library (SMT-LIB)

- Initiative to collect benchmark formulas in standard format.
- Formats for theories, logics (formula classes), benchmarks.
- SMT-LIB format specification by Ranise and Tinelli.
- Non-trivial to devise due to diverse domains.
- Formula language:
  - ▶ prefix notation
  - ▶ standard logical connectives
  - ▶ applications of theory predicates, functions

# SMT-COMP

- SMT solvers compete on benchmarks in SMT-LIB format.
- Idea arose at PDPAR '04.
- Other automated reasoning competitions:
  - ▶ CASC: first-order provers, CADE
  - ▶ SAT Competition: propositional SAT, SAT conference
  - ▶ Termination Competition: termination of rewriting systems, RTA
- Why hold at CAV '05?
  - ▶ Main application of SMT is for verification.
  - ▶ PDPAR '05 is co-located with CAV '05.

# Goals of SMT-COMP at CAV '05

- Collect benchmarks in SMT-LIB format.
- Encourage solvers to support SMT-LIB format.
- Spur innovation through friendly competition.
- Connect SMT implementors with potential users in verification.

# Competition Format

- Solvers run on dedicated machines, timeout 10min.
- Can report sat/unsat/unknown.
- Divisions:
  - ▶ QF\_UF: quantifier-free EUF formulas
  - ▶ QF\_RDL: difference logic over reals
  - ▶ QF\_IDL: difference logic over integers
  - ▶ QF\_UFIDL: difference logic + EUF over integers
  - ▶ QF\_LRA: linear real arithmetic
  - ▶ QF\_LIA: linear integer arithmetic
  - ▶ QF\_AUFLIA: arrays + EUF + LIA

# Benchmark Formulas

- Collected mostly from verification, some planning.
- Most existed already in other formats.
- Provided by
  - ▶ A. Oliveras, B. Dutertre, P. Manolios, L. Pike, J. Shin, S. Srinivasan, O. Strichman.
  - ▶ TSAT++ group, MathSAT, SAL, UCLID, WiSA.
- Translated by Clark and Albert.

# Was SMT-COMP a Success?

6 months ago...

- 0 benchmarks in SMT-LIB format.
- 0 solvers parsing SMT-LIB.
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- 12 (submitted) solvers parsing SMT-LIB.
- 7 logics specified in SMT-LIB.

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**SMT-COMP was a big success!**

# Results for QF\_UF

Solver	Score	Time	Unsat	Sat	Unknown	Wrong
Barcelologic Tools	39	1758.2	31	8	11	0
Yices	37	1801.4	29	8	13	0
MathSat	33	2186.2	26	7	17	0

# QF\_RDL

Solver	Score	Time	Unsat	Sat	Unknown	Wrong
BarceloLogicTools	41	940.8	36	5	9	0
Yices	37	1868.0	32	5	13	0
MathSat	37	2608.0	32	5	13	0

# QF\_IDL

Solver	Score	Time	Unsat	Sat	Unknown	Wrong
BarceloLogicTools	47	1131.2	38	9	4	0
Yices	47	1883.2	38	9	4	0
MathSat	46	1295.4	35	11	5	0

# QF\_UFIDL

Solver	Score	Time	Unsat	Sat	Unknown	Wrong
BarceloLogicTools	45	305.2	43	2	4	0
Yices	36	1989.8	34	2	13	0
MathSat	22	1055.5	20	2	27	0

# QF\_LRA

Solver	Score	Time	Unsat	Sat	Unknown	Wrong
Simplics	49	361.8	42	7	1	0
Yices	47	310.6	42	5	3	0
MathSat	42	208.3	41	1	8	0

# QF\_LIA

Solver	Score	Time	Unsat	Sat	Unknown	Wrong
Yices	41	1873.0	28	13	13	0
MathSat	32	1887.2	23	14	17	1
Ario	30	2402.4	18	12	24	0

# QF\_AUFLIA

Solver	Score	Time	Unsat	Sat	Unknown	Wrong
Yices	49	46.8	35	14	3	0
CVC	34	243.0	34	0	18	0
CVC Lite	34	769.3	28	6	18	0