

The 4th Competition on Syntax-Guided Synthesis

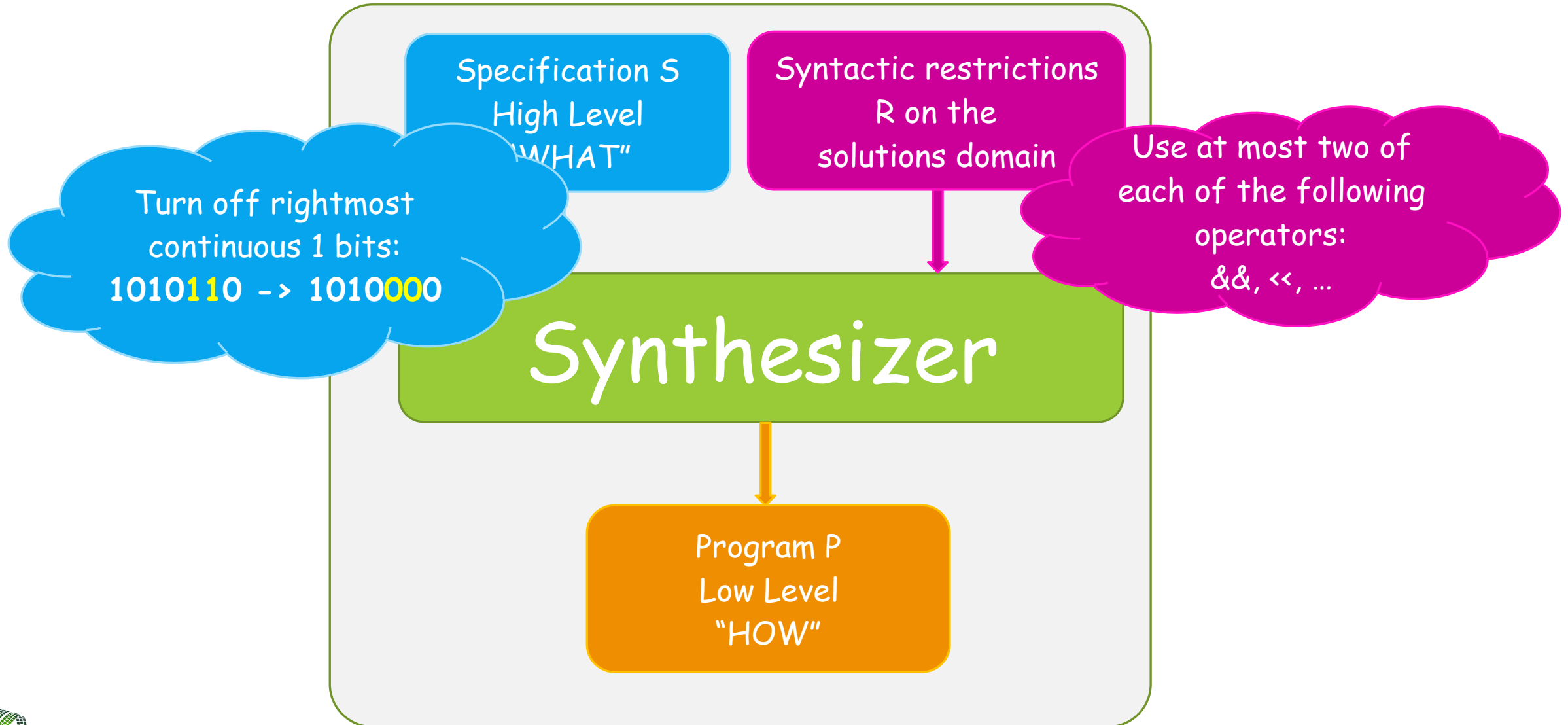


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Rishabh Singh and Armando Solar-Lezama

SyGuS

Idea and Definition
in a Nutshell

New Trends in Synthesis



Syntax Guided Synthesis - Idea

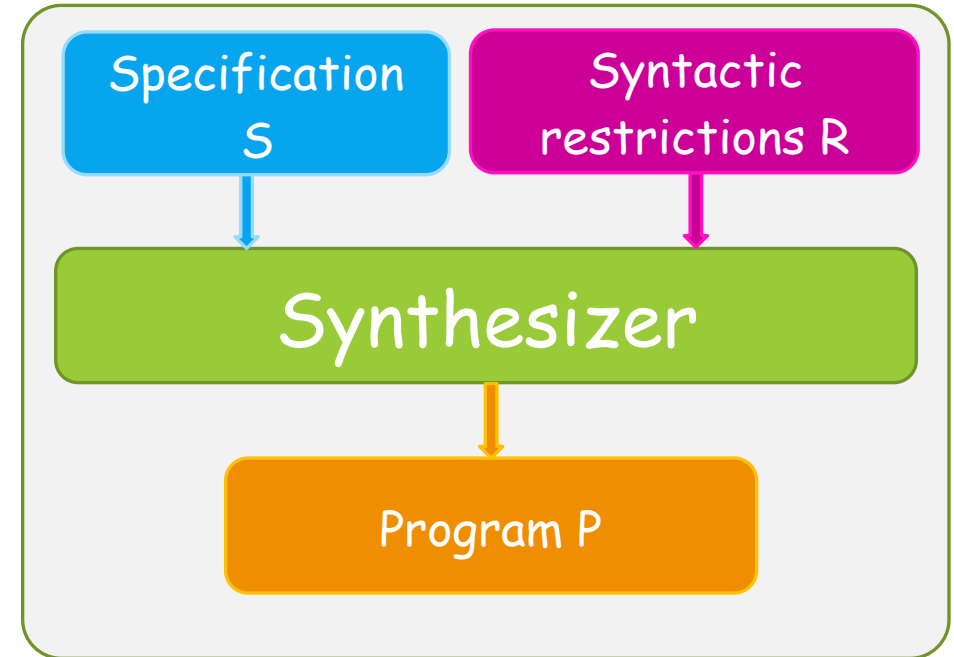
Motivation:

- Tractability
- Combine

human expert insights with

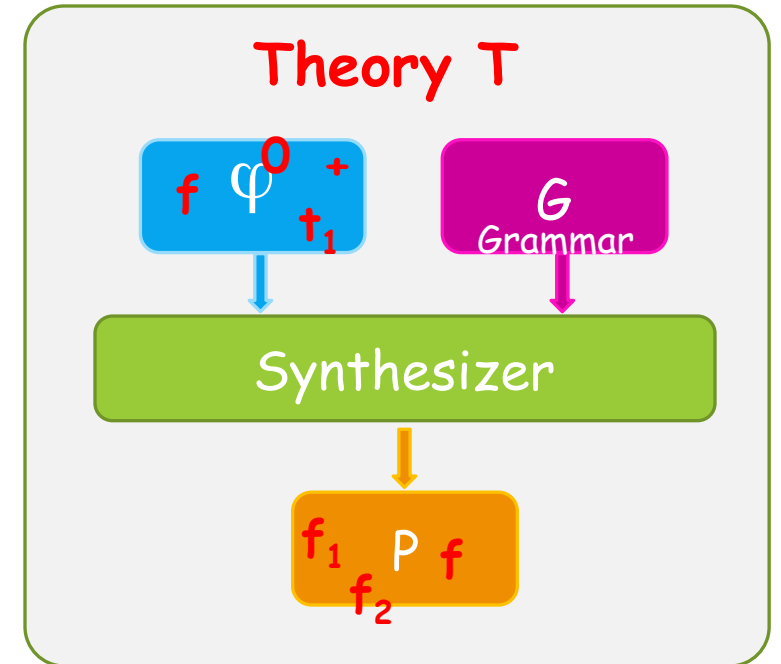
computers exhaustiveness & rapidness

- Benefit progress SAT & SMT Solvers



Syntax-Guided Synthesis (SyGuS) Problem

- Fix a background **theory T**: fixes types and operations
- Function to be synthesized: **name f** along with its type
 - ❖ General case: multiple functions to be synthesized
- Inputs to SyGuS problem:
 - ❖ **Specification φ**
Typed formula using symbols in **T** + symbol **f**
 - ❖ **Context-free grammar G**
Characterizing the set of allowed **expressions** $[[G]]$ (in theory **T**)
- **Computational problem**:
Find **expression e** in $[[G]]$ such that $\varphi[f/e]$ is valid (in theory **T**)



SyGuS-Comp 17

The 5th competition on Syntax Guided
Synthesis

Solvers

- **CVC4 2017** - Andrew Reynolds (Univ. of Iowa), Cesare Tinelli (Univ. of Iowa) and Clark Barrett (NYU)
- **EUSolver 2017** - Arjun Radhakrishna (MSR) and Abhishek Udupa (MSR)
- **Euphony** - Woosuk Lee (Penn), Arjun Radhakrishna (MSR) and Abhishek Udupa (MSR)
- **DryadSynth** - KangJing Huang, Xiaokang Qiu, and Yanjun Wang (all from Purdue Univ.)
- **LoopInvGen** - Saswat Padhi (UCLA) and Todd Millstein (UCLA)
- **E3Sovler** - Ammar Ben Khadra (University of Kaiserslautern)

Tracks

- General
- Inv
- CLIA
- PBE Strings
- PBE Bitvectors

Tracks Participation

- **CVC4-2017:** all 5 tracks
- **EUSolver-2017:** all 5 tracks
- **Euphony:** all 5 tracks
- **DryadSynth:** CLIA and INV tracks
- **LoopInvGen:** INV track
- **E3Solver:** PBE Bitvectors track

New Benchmarks

- Invariant Generation (7)
by Saswat Padhi (UCLA)
- Program Repair (18) [FSE 2017, ISSTA 2017]
by Xuan Bach D Le (SMU), David Lo (SMU) and Claire Le Goues (CMU)
- Crypto Circuits (214) [CAV 2016]
by Chao Wang (USC)
- Instruction Selection (28)
by Sebastian Buchwald and Andreas Fried (KIT)

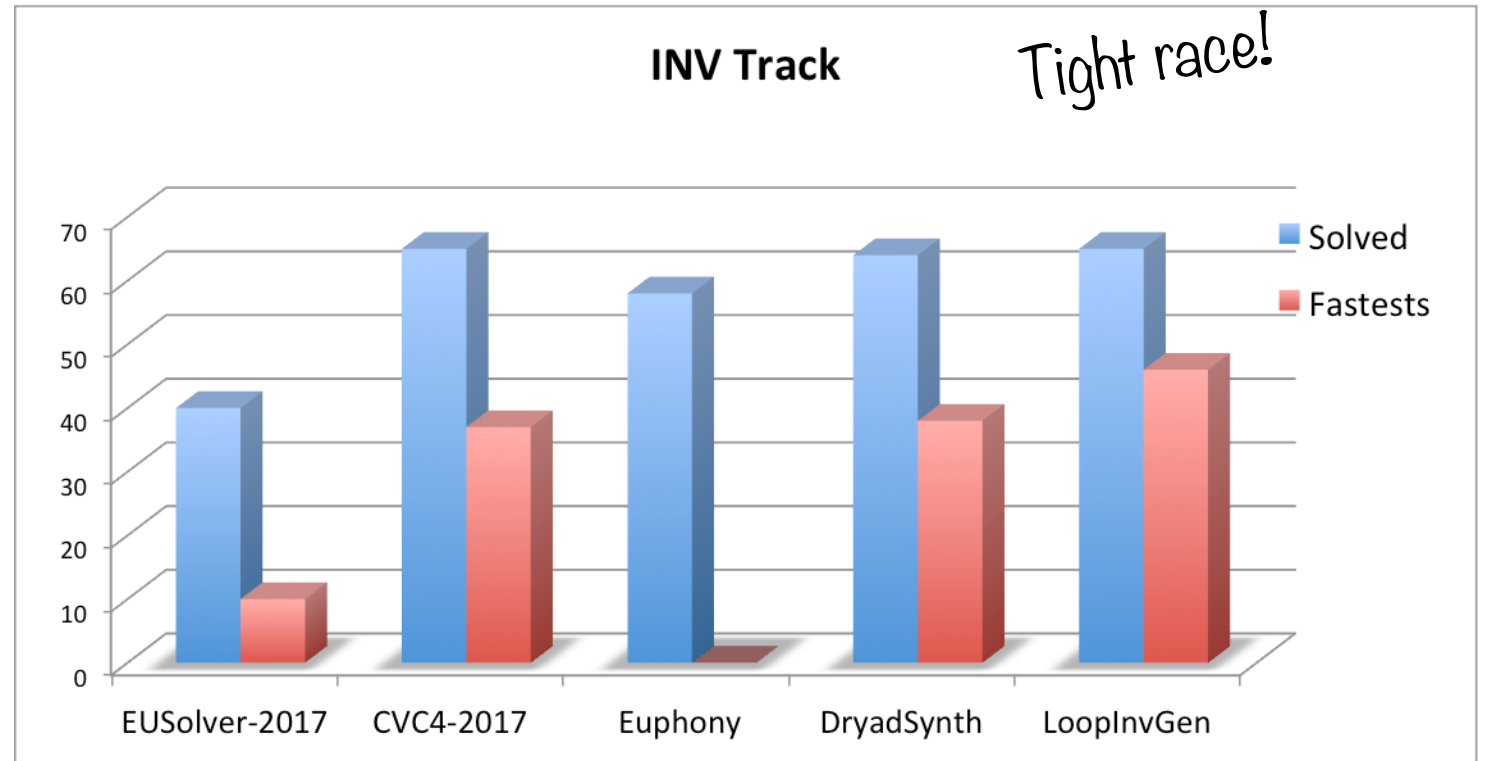
Inv Track (74)



LoopInvGen
65/46



DryadSynth & CVC4₂₀₁₇
64/38 65/37



CLIA Track (73)

Winner of last year



Last year 73/50

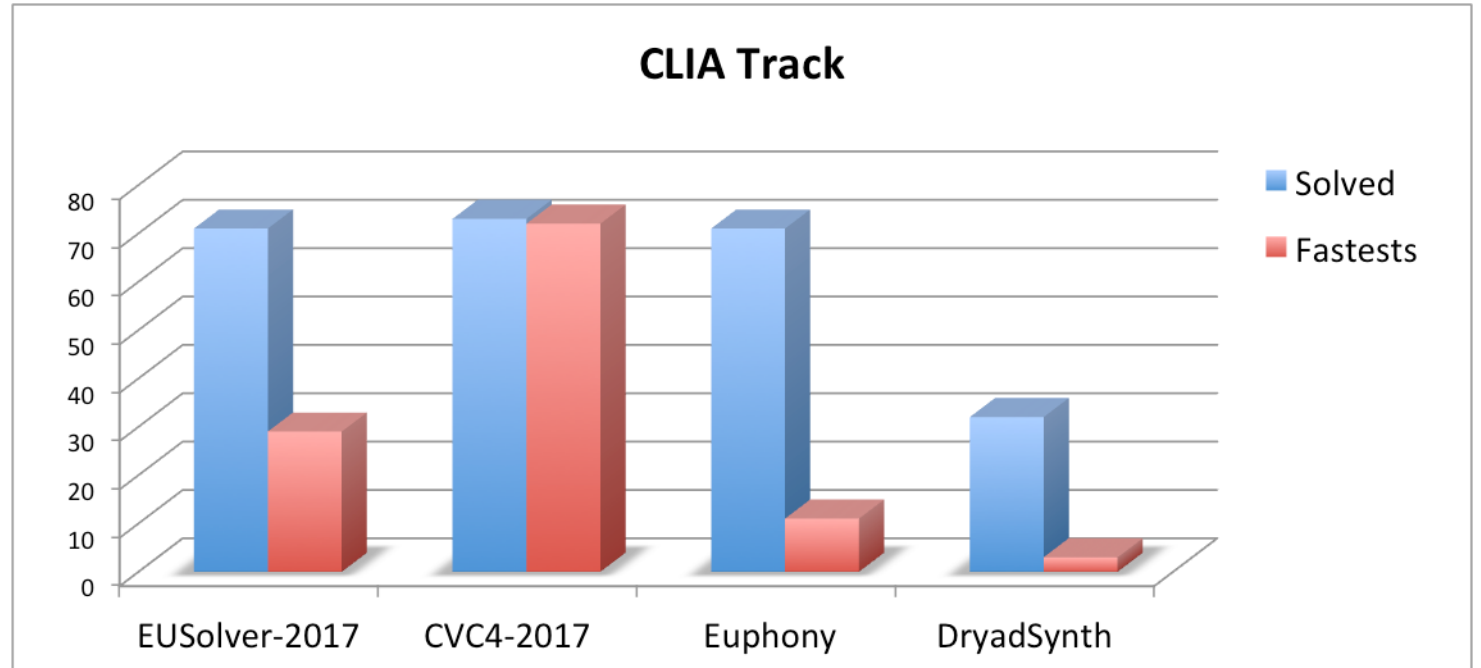


EUSolver₂₀₁₇
71/29



Euphony
71/11

Outstanding improvement!
Last year 37/11



PBE Stings (108)



Outstanding improvement!
Last year solved 18

CVC4₂₀₁₇
89/49

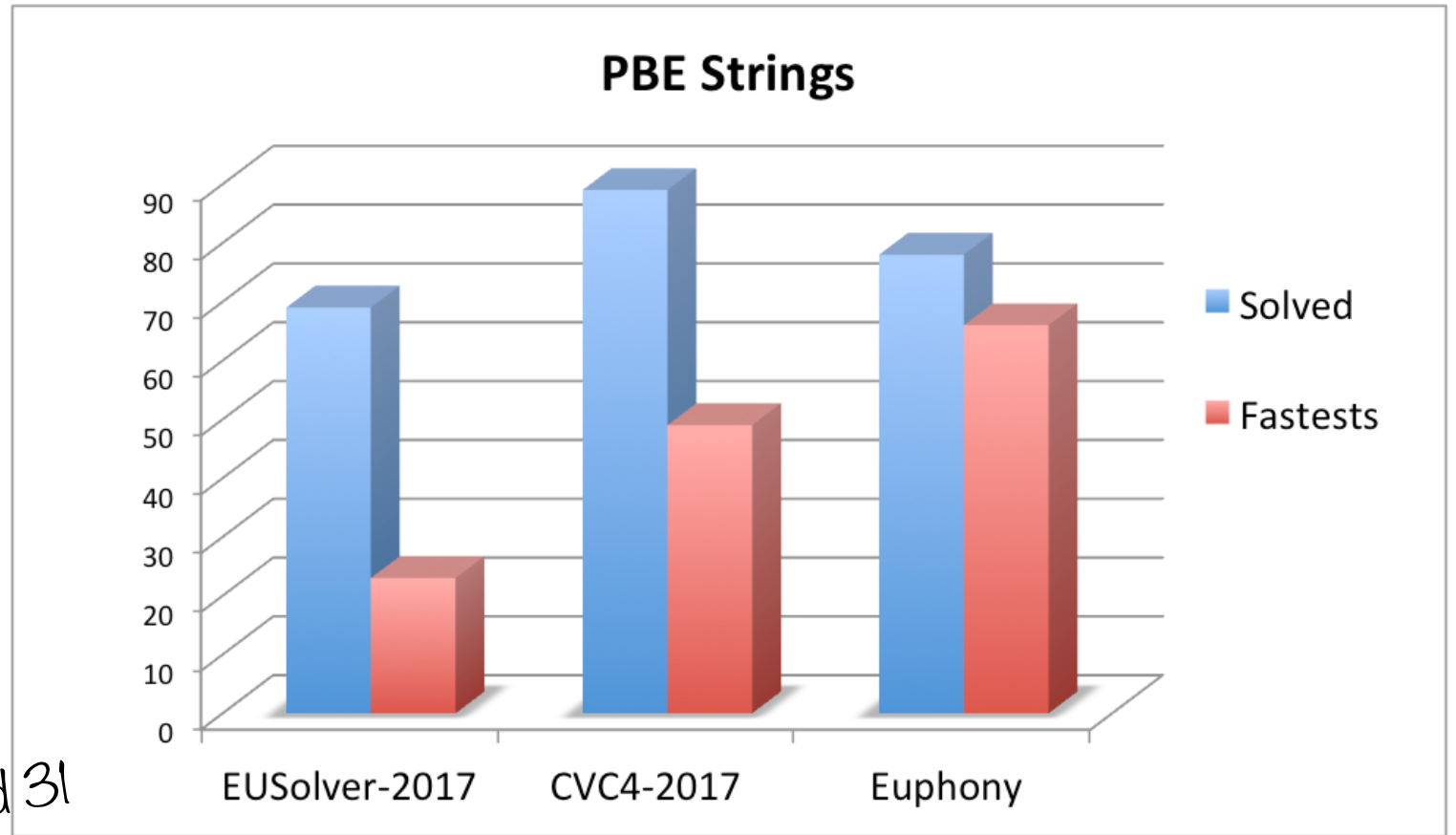


Euphony
78/66



EUSolver₂₀₁₇
69/23

Winner of last year
Last year solved 31



PBE Bitvectors (750)



100% solved!

E3 Solver

750/692



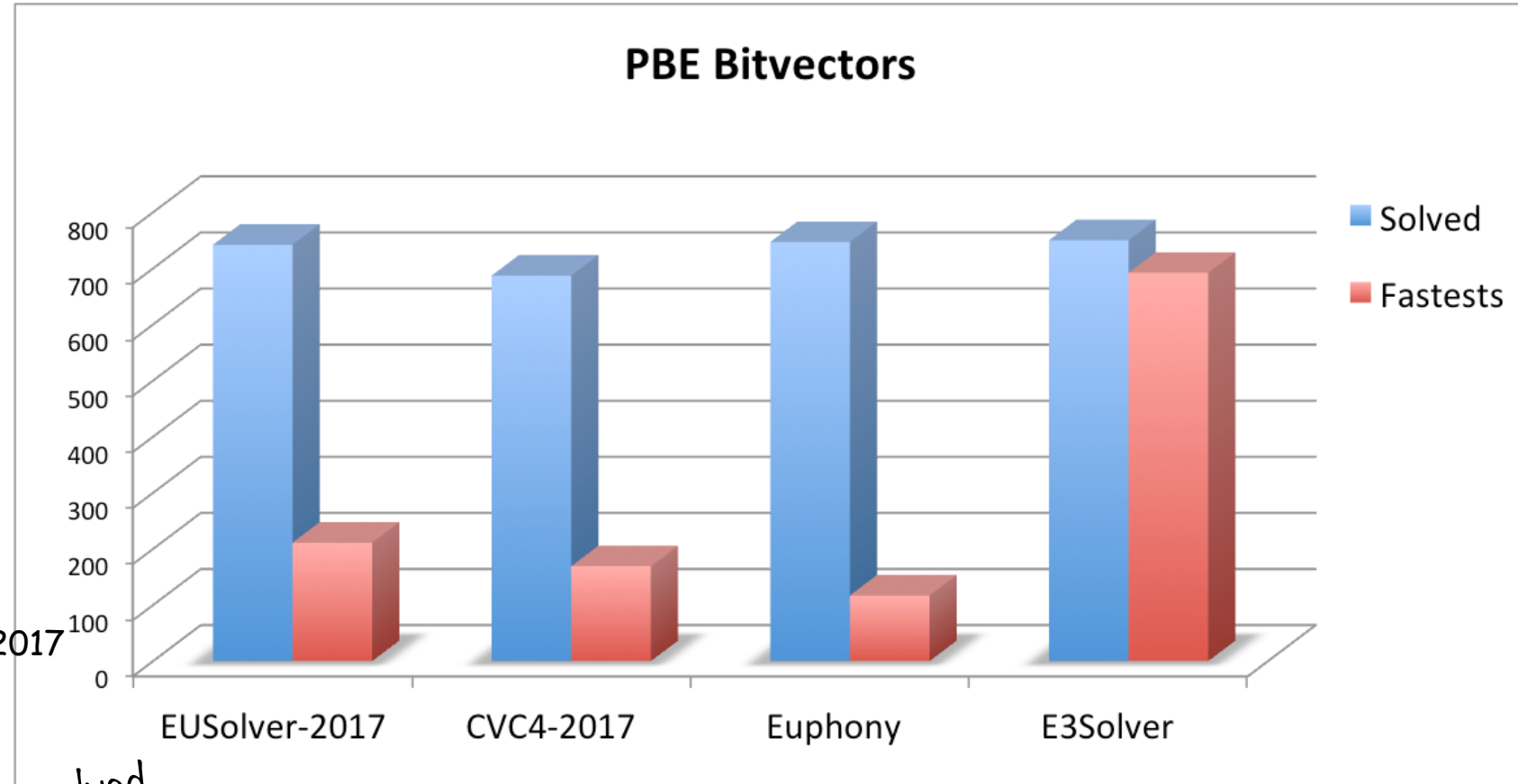
Euphony & EUSolver²⁰¹⁷

747/117

742/211

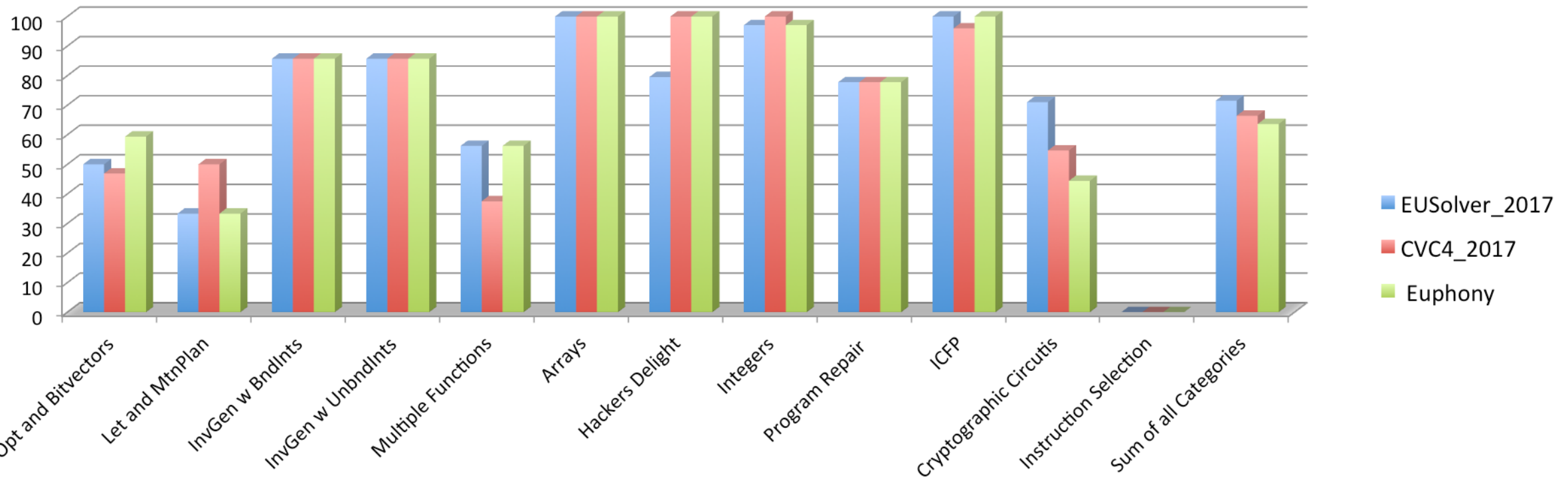
Winner of last
year

Last year solved
730



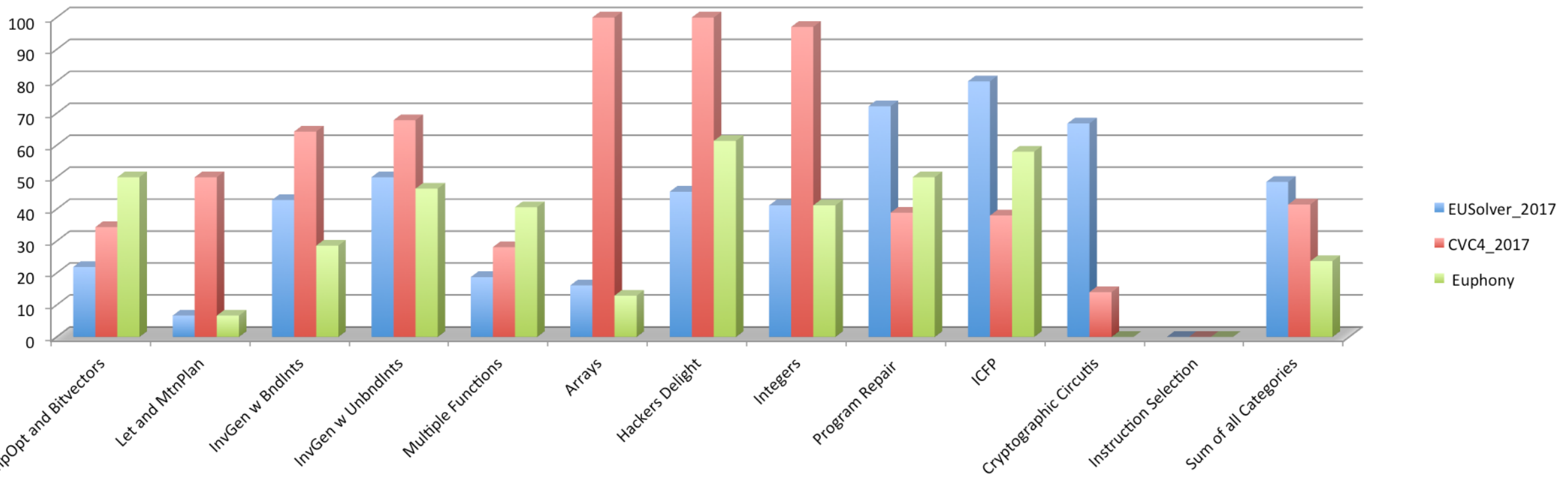
General Track (569) - Solved

Percentage of Benchmarks Solved in the General Track
per Solver per Category



General Track (569) - Fastest

Percentage of Benchmarks Solved among the Fastest in the General Track per Solver per Category



General Track (569)

Category	Number of Benchmarks	Solved			Fastest			First Place
		CVC4-2017	EUSolver-2017	Euphony	CVC4-2017	EUSolver-2017	Euphony	
Compiler Optimizations and Bit Vectors	32	16	15	19	7	11	16	Euphony
Let and Motion Planning	30	10	15	10	2	15	2	CVC4
Invariant Generation with Bounded Ints	28	24	24	24	12	18	8	CVC4
Invariant Generation with Unbounded Ints	28	24	24	24	14	19	13	CVC4
Multiple Functions	32	18	12	18	6	9	13	Euphony
Arrays	31	31	31	31	5	31	4	CVC4
Hackers Delight	44	35	44	44	20	44	27	CVC4
Integers	34	33	34	33	14	33	14	EUSolver
Program Repair	18	14	14	14	13	7	9	EUSolver
ICFP	50	50	48	50	40	19	29	EUSolver
Cryptographic Circuits	214	152	117	95	143	30	0	EUSolver
Instruction Selection	28	0	0	0	0	0	0	None
Sum of all Categories	569	407	378	362	276	236	135	EUSolver



EUSolver₂₀₁₇
407/276



CVC4₂₀₁₇
378/236



Euphony
362/135

General Track Summary & Discussion

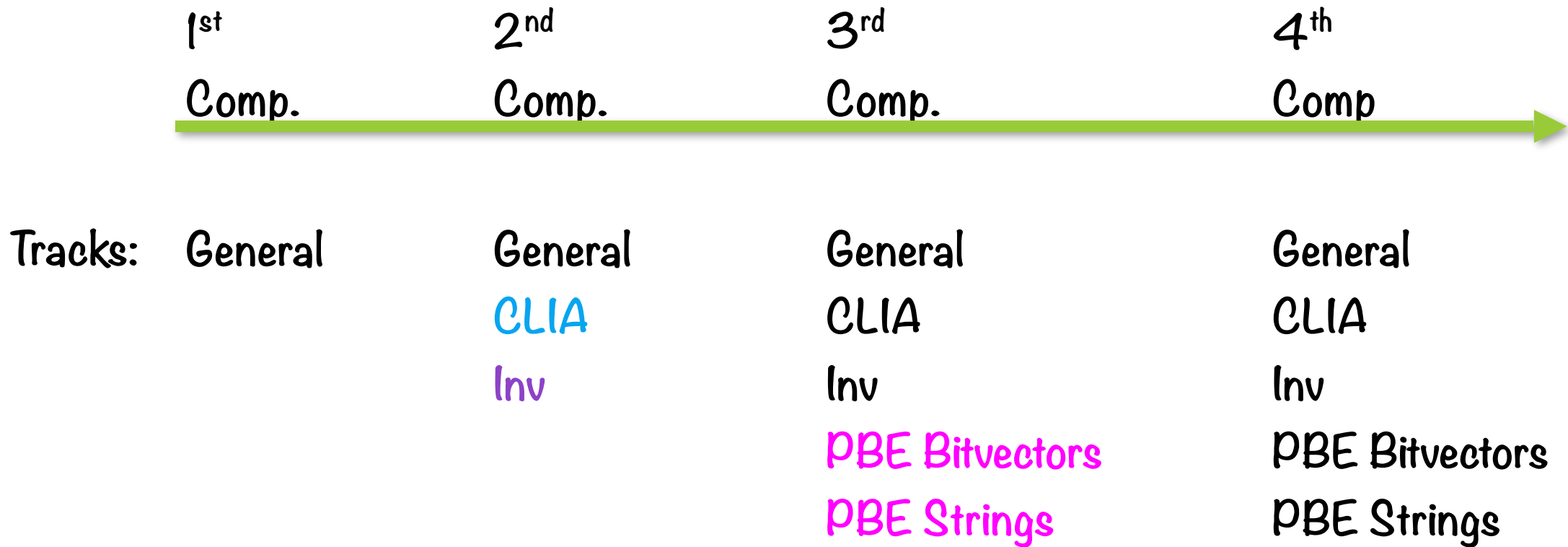
- EUSolver solved more benchmarks, and more benchmarks among the fastest
- CVC4 was second to solve more benchmarks and more benchmarks among the fastest.
- In term of categories
 - CVC4 won 6 categories: Arrays, Let & MP, HD, Integers, InvGen wBndInts, InvGen wUnbndInts
 - EUSolver won 3 categories: Program Repair, ICFP, Crypto Crkts
 - Euphony won 2 categories: Multiple Functions, Compiler Optimizations

Expression Sizes

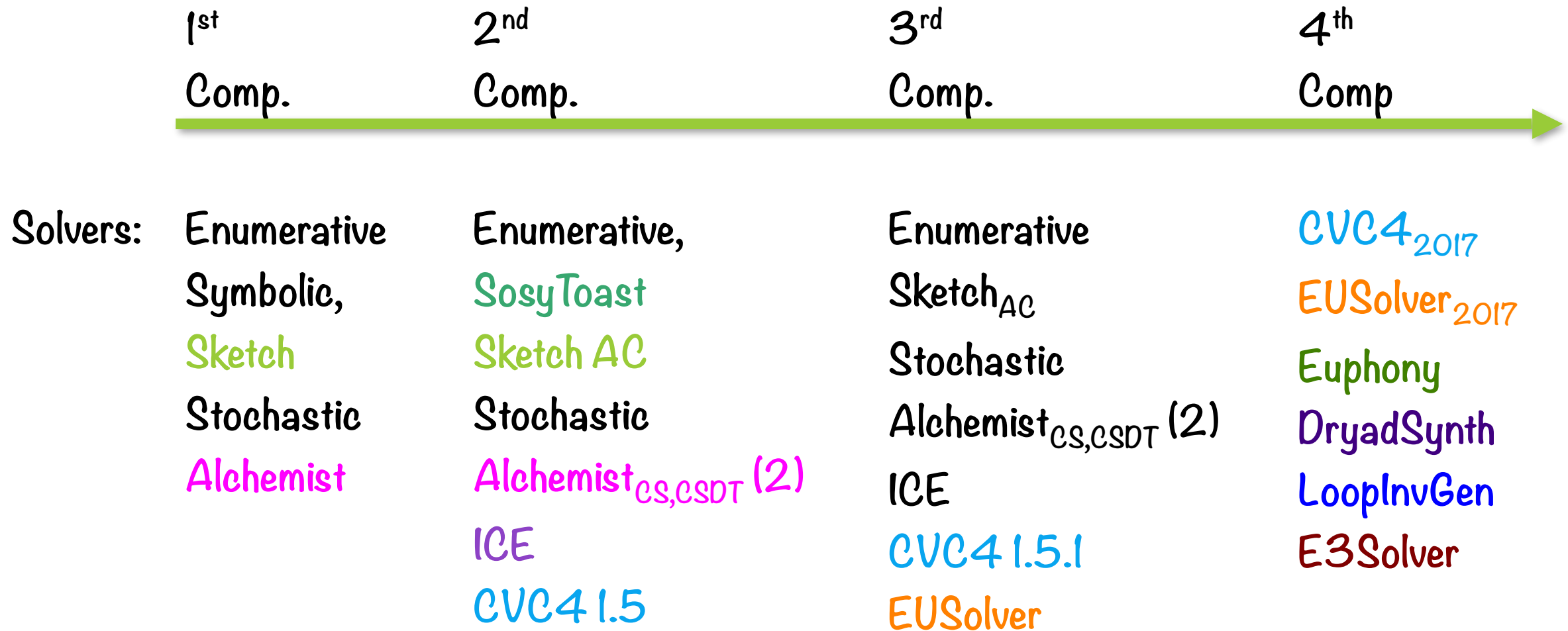
Solver	Sum ExprSize	Max ExprSize	Avg ExprSize
CVC4 ₂₀₁₇	6193196	1843271	16559.34759
EUSolver ₂₀₁₇	16333	2551	40.62935323
Euphony	16009	2551	44.34626039

CVC4₂₀₁₇ generates quite big expressions...

Timeline View - Tracks



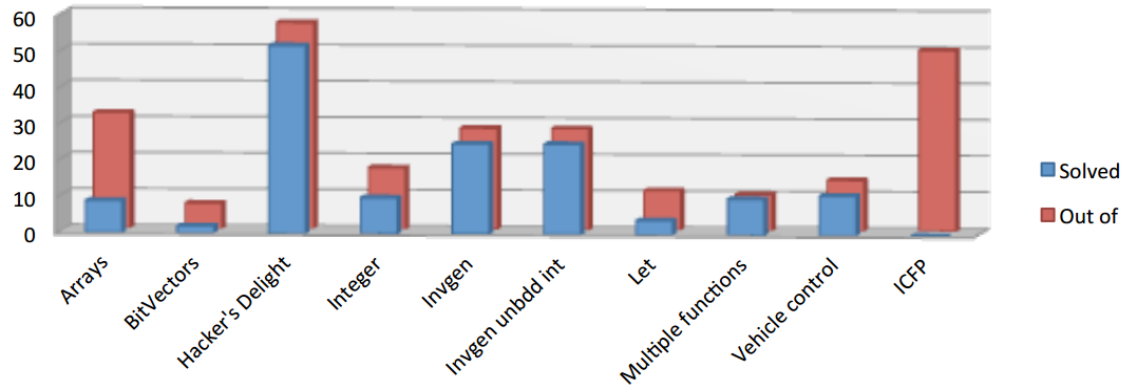
Timeline View - Solvers



General Track 1st vs. 4th Competitions

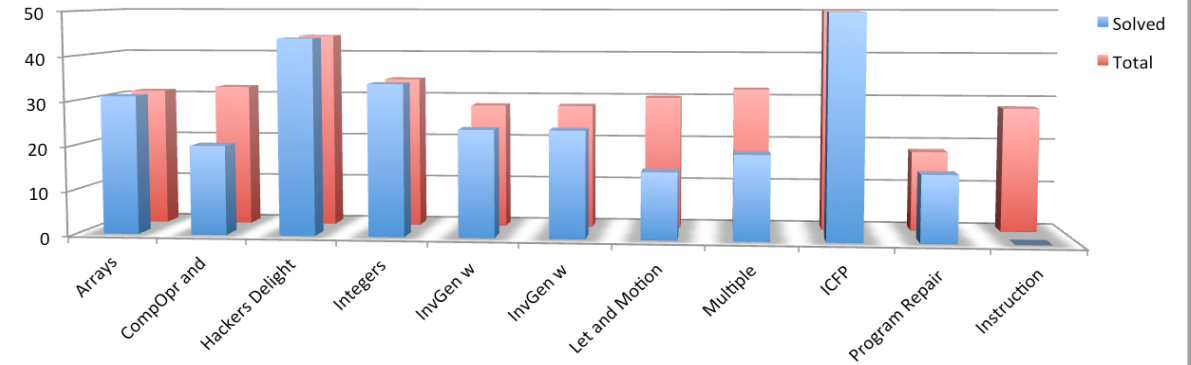
1st

Number of Benchmark Solved out of the Total per Category



4th

Number of Benchmarks Solved out of the Total per Category



Timeline View - Successes & Challenges

1st
Comp.

2nd
Comp.

3rd
Comp.

4th
Comp.

Successes:

Hackers' Delight
Invariant Gen

Arrays
Max $n \leq 15$

More benches
ICFP
Faster

PBE-Stings
Crypto Crkts
Program Repair
Expr Size Improv.

Challenges:

Arrays
Max $n > 4$
Let
MultFunc

Let
MultFunc
ICFP
CompOpt

Let
MultFunc
CompOpt
PBE-Strings

Let
MultFunc
CompOpt
Instruction Selection

SyGuS-Comp 17

Solvers' Strategies

Solvers' Strategies

E3Solver presentation:

Ammar Ben Khadra

CVC4₂₀₁₇ presentation:

Andy Reynolds

DryadSynth:

Xiaokang Qiu

LoopInvGen:

... on behalf of authors

Euphony:

...

ESolver: