Constraint Solvers for the Working PL Researcher

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The SAT/SMT Revolution

- hardware verification
- software verification
- software synthesis & repair
- network configuration synthesis
- biological modeling
- architecture
Boolean SATisfiability

\[(\text{gin} \lor \text{tonic}) \land (\text{minor} \Rightarrow \neg \text{gin}) \land \text{minor}\]

Solution:

\[
\begin{align*}
\text{minor} & \mapsto T \\
\text{gin} & \mapsto F \\
\text{tonic} & \mapsto T
\end{align*}
\]
Satisfiability Modulo Theories

\[(\text{gin} \lor \text{tonic}) \land (\text{age} \leq 21 \Rightarrow \text{abv} = 0) \land (\text{age} = 17) \land (\text{gin} \Rightarrow \text{abv} \geq 40)\]

Solution:

- \text{age} \mapsto 17
- \text{abv} \mapsto 0
- \text{gin} \mapsto F
- \text{tonic} \mapsto T

theory of Linear Integer Arithmetic
Popular Solvers

Microsoft

Stanford

SRI

JKU Linz, Austria

SMT competition: [http://smtcomp.sourceforge.net](http://smtcomp.sourceforge.net)

```
(declare-fun (Int) age)
(declare-fun (Int) abv)
```
Plan for Today

How to use Z3 for:
1. Constraint programming
2. Program verification
3. Program synthesis
Problem: Array Partitioning

Partition an array of size $N$ evenly into $P$ sub-ranges

$N = 8$

$P = 4$

$SZ_1$  $SZ_2$  $SZ_3$  $SZ_4$
Problem: Array Partitioning

Partition an array of size $N$ evenly into $P$ sub-ranges

$N = 10$

$P = 4$

$sZ_1$ $sZ_2$ $sZ_3$ $sZ_4$
Problem: Array Partitioning

Partition an array of size $N$ evenly into $P$ sub-ranges

$N = 10$

Can we always make them differ by at most 1?
to the rescue!
CEGIS

\[ N_0 \rightarrow \text{synthesize} \rightarrow C \rightarrow \text{verify} \rightarrow \{N_0, N_1, \ldots, N_k\} \rightarrow \text{verified for all } N! \rightarrow \text{wrong for } N = N_k \]