Intro to Z3 solver

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@M0LECONBEGINNER

What is Z3?

https://github.com/Z3Prover/z3

Theorem prover

Efficient SMT solver

MAGIC!

Symbolic logic engine

A “model”?

Symbolic variables

(x)

(x)

(x)

Operations and constraints

$(x) \geq 42$

SMT solver

Problem of determining whether a mathematical formula is *satisfiable*, i.e. there **exists solutions given the relationships between the variables and the defined constraints**

Example

```
x & y & (x ^ z)
```

x	y	z	x & y & (x ^ z)
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

We do security, not math. So?

- Formal testing of functional requirements (input -> output)
- Automatic static analysis looking for vulnerabilities
- Symbolic execution
- Automate finding of input to reach a specific point of the program (i.e. the “win” function)

Real example: **angr** https://angr.io/
(true, real, magic)

SMT Solvers for Software Security

Z3 with python

https://ericpony.github.io/z3py-tutorial/

```
pip install z3-solver
```

Recall math problems at high school?

1. Define variables
   and create a “solver”
2. Add constraints from your problem
3. Solve!

```python
from z3 import *

# Define vars and solver
x = BitVec('x', 1)
y = BitVec('y', 1)
z = BitVec('z', 1)
s = Solver()

# Add constraints
s.add((x & y & (x ^ z) == 1))

# Solve!
if s.check() == sat:
  m = s.model()
  print(m)
```

Main symbolic variable types and operators

- **`Int`**
- **`Real`**
- **`Bool`**
- **`BitVec[bitsize]`**

z3 variables can then be used as any other python variable for computations. Standard operators (+, -, &, ^, <<, ...) are supported.

Alternatively z3 specific operator classes can be used **`And,Or,Xor,Not,...`**

Special techniques for representing control flows and other advanced modeling e.g. **`If, Then, Sum, Distinct, ForAll, Exists...`**

Try it yourself: 8-Queens problem

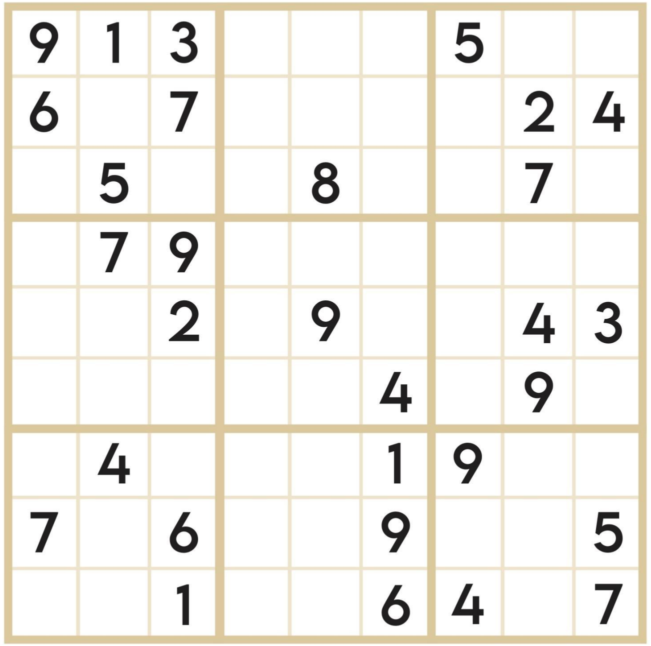
Place 8 chess queens on an 8×8 chessboard so that no two queens threaten each other, i.e. max 1 queen for row, column and diagonal

Hint
Checkout the `Sum` operator!

Challenge: solving Sudoku

Hint
Checkout the `Distinct` operator!

https://workshop.m0lecon.it/challenges#sudoku-30



9	1	3				5		
6		7					2	4
	5			8			7	
	7	9						
		2		9			4	3
					4		9	
	4				1	9		
7		6			9			5
		1			6	4		7

Challenge: easy crackme, find the hidden key

https://workshop.m0lecon.it/challenges#crackmat-32

1. Open the executable in a decompiler (Ghidra, IDA, Binary Ninja)
2. Rewrite the model in Z3
3. Solve

Easy right?

Challenge: Android Guessing Game

Let’s recap. Can you recover the original number guess??

https://workshop.m0lecon.it/challenges#GuessingGame-33