CS409
Software Testing

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Slides adapted from Z3 website (https://www.rise4fun.com/z3)

Administrative Info

- Progress Report released and due on 4 December (this week) at 11.59pm.
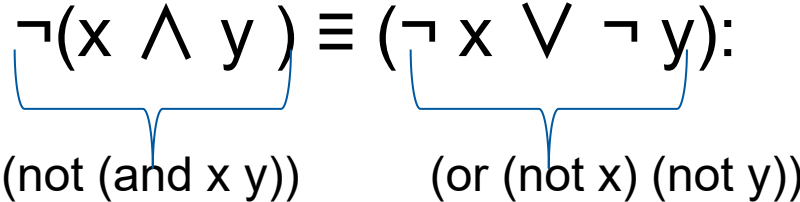 - Start early!

What is Z3?

- State-of-the-art SMT solver from Microsoft Research.

- Used to check the satisfiability of logical formulas over one or more theories.

- It is a low level tool that is often used as a component in the context of other tools that require solving logical formulas

How do I write script for Z3?

- Z3 input format is an extension of the SMT-LIB 2.0 standard.

- A Z3 script is a sequence of commands. Z3 maintains a stack of user provided formulas and declarations. These are the **assertions** provided by the user.

  - **declare-const** declares a constant of a given type.

  - **declare-fun** declares a function.

  - **assert** adds a formula into the Z3 internal stack.

  - **check-sat** returns sat if the set of formulas in the Z3 stack is satisfiable.

  - When the command **check-sat** returns sat, the command **get-model** can be used to retrieve an interpretation that makes all formulas on the Z3 internal stack true.

Exercise 1:
Propositional and Predicate Logic in Z3

- Use functions to represent the propositions x and y

- Check if $\neg(x \wedge y) \equiv (\neg x \vee \neg y)$:

  (not (and x y))   (or (not x) (not y))

- Go to https://www.rise4fun.com/z3 and try to check this formula

  (declare-fun x () Bool)
  (declare-fun y () Bool)
  (assert (= (not(and x y)) (or (not x)(not y))))
  (check-sat)

Exercise 2:
Using Z2 for Arithmetic

```
(declare-const a Int)
(declare-fun f (Int Bool) Int)
(assert (> a 10))                        the constant a must be greater than 10
(assert (< (f a true) 100))
(check-sat)                    function *f* applied to *a* and *true* must return a value less than 100
```

- Go to https://www.rise4fun.com/z3 and try to check this formula

- Add the assertion "(get-model)" to the script above. Explain what you understand from the output

Exercise 3:
Solving Equations using Z3

- Can you find a solution for x and y in the following equations using Z3?

- 3x + 2y = 36

- 5x + 4y = 64

- Go to https://www.rise4fun.com/z3 and try to check this formula

- Add the assertion "(get-model)" to the script above. Explain what you understand from the output

Exercise 4:
Using Z3 as a calculator

- Z3 also has support for division, integer division, modulo and remainder operators etc.

- Use Z3 to calculate the following and store the result in constants a1, a2 and a3:

  (a) 16 mod 2

  (b) 16 divided by 4

  (c) The remainder after dividing 16 by 5

Example Operators:
(declare-const a Int)
(declare-const r1 Int)
(declare-const r2 Int)
(declare-const r3 Int)
(assert (= a 10))
(assert (= r1 (div a 4))); integer division
(assert (= r2 (mod a 4))); mod
(assert (= r3 (rem a 4)));remainder
(declare-const b Real)
(declare-const c Real)
(assert (>= b (/ c 3.0)))
(assert (>= c 20.0))
(check-sat)
(get-model)

Exercise 5:
Using Z3 at the restaurant

- Encode the following menu choices into Z3 and check what a customer could buy using exactly $15.05

  - Mixed fruit $2.15

  - French Fries $2.75

  - Side Salad $3.35

  - Hot Wings $3.55

  - Mozzarella Sticks $4:20

  - Sampler Plate $5:80

- Is it possible to order everything on the menu?

- Does this problem have only one solution? If it does not, what are the other solutions?

- Go to https://www.rise4fun.com/z3 and try to check this formula

Hint: Use (declare-const a Real) for representing floating point

References

- https://www.rise4fun.com/Z3/tutorial/guide

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  - Start early!

  - Discuss with your groupmate!