

# CVC5 in Lean 4: cvc.lean

API, Safety, tactics, and integration with lean-auto

repository: <https://github.com/anzenlang/cvc.lean>

slides available at <https://anzenlang.io/blog>



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# Overview: Lean libraries

## lean-smt

**smt** tactic:

- encodes hypotheses/goal(s) to SMT
- solves using CVC5
- reconstructs a proof (Lean term)

## cvc.lean

high(er)-level API:

- bells and whistles
- basic API, safe(r) API
- **falsifiable?** tactic with lean-auto

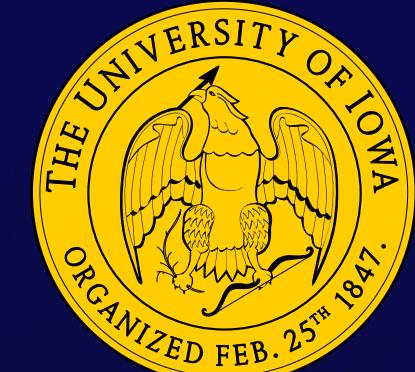
## lean-cvc5

"simply" lifts CVC5 C++ types/functions to Lean 4, almost untouched

## CVC5 C++ API



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# Extending lean-cvc5

Currently exposes little of the CVC5 API

We are merging soon™

- ✓ most of the functions corresponding to SMT-LIB commands
- ✓ quantified terms and quantifier elimination
- ✓ interpolants and abducts
- ✓ function synthesis
- information retrieval on unknown result



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# API: Terms and SMT Commands



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# Comparison: Term creation

```
-- `lean-cvc5`  
def mkTerm : TermManager → (kind : Kind) → (children : Array Term) → Except Error Term
```

```
-- `cvc.lean` basic API: specialized constructors  
def mult (lhs rhs : Term) : ManagerM Term  
def eq (lhs rhs : Term) : ManagerM Term  
def mkIte (cnd thn els : Term) : ManagerM Term
```

```
-- `cvc.lean` safe API: specialized constructors over strongly-typed terms  
def mult [ArithLike α] (a b : Term α) : ManagerM (Term α)  
def eq (lhs rhs : Term α) : ManagerM (Term Bool)  
def mkIte (cnd : Term Bool) (thn els : Term α) : ManagerM (Term α)
```

[github.com/anzenlang/cvc.lean/CvcTest/Demo/Cvc5Summit/Comp.lean](https://github.com/anzenlang/cvc.lean/CvcTest/Demo/Cvc5Summit/Comp.lean)



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# Comparison: SMT

```
-- `lean-cvc5`  
def assertFormula : (term : Term) → SolverT m Unit  
def getValue : (term : Term) → SolverT m Term  
def checkSat : SolverT m Result
```

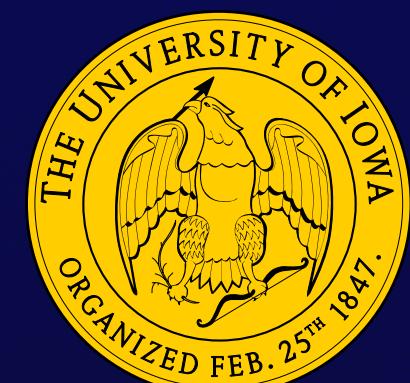
```
-- `cvc.lean` basic API  
def assert (formula : Term) : SmtM Unit  
def getValue (term : Term) : SmtM Term  
def checkSat? : SmtM (Option Bool)
```

```
-- `cvc.lean` safe API: typed terms, only allow (un)sat-specific commands when legal  
def assert (formula : Term Bool) : SmtM Unit  
def getValue {α : Type} [I : ValueOfSafeTerm α] (term : Term α) : Smt.SatM α  
def checkSat  
  (ifSat : Smt.SatT m α) (ifUnsat : Smt.UnsatT m α) (ifUnknown : Smt.UnknownT m α)  
  : SmtT m α
```

[github.com/anzenlang/cvc.lean/CvcTest/Demo/Cvc5Summit/Comp.lean](https://github.com/anzenlang/cvc.lean/CvcTest/Demo/Cvc5Summit/Comp.lean)



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# Comparison

A few examples:

- short and simple comparison of term creation/SMT commands  
[CvcTest/Demo/Cvc5Summit/Comp.lean](#)
- int-valued function minimization example  
[CvcTest/Demo/SimpleMinimizer.lean](#)
- induction and pre-image computation on transition system  
[CvcTest/Safe/Sys.lean](#)  
[CvcTest/Safe/SysDemoSw.lean](#)



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# Tactics: Theorem proving with Cvc5



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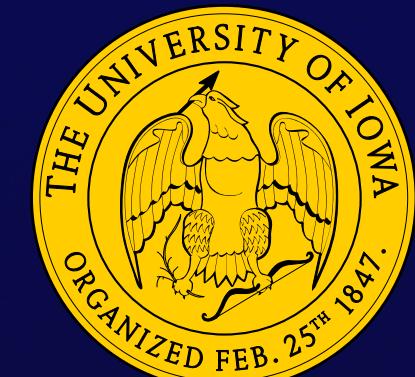
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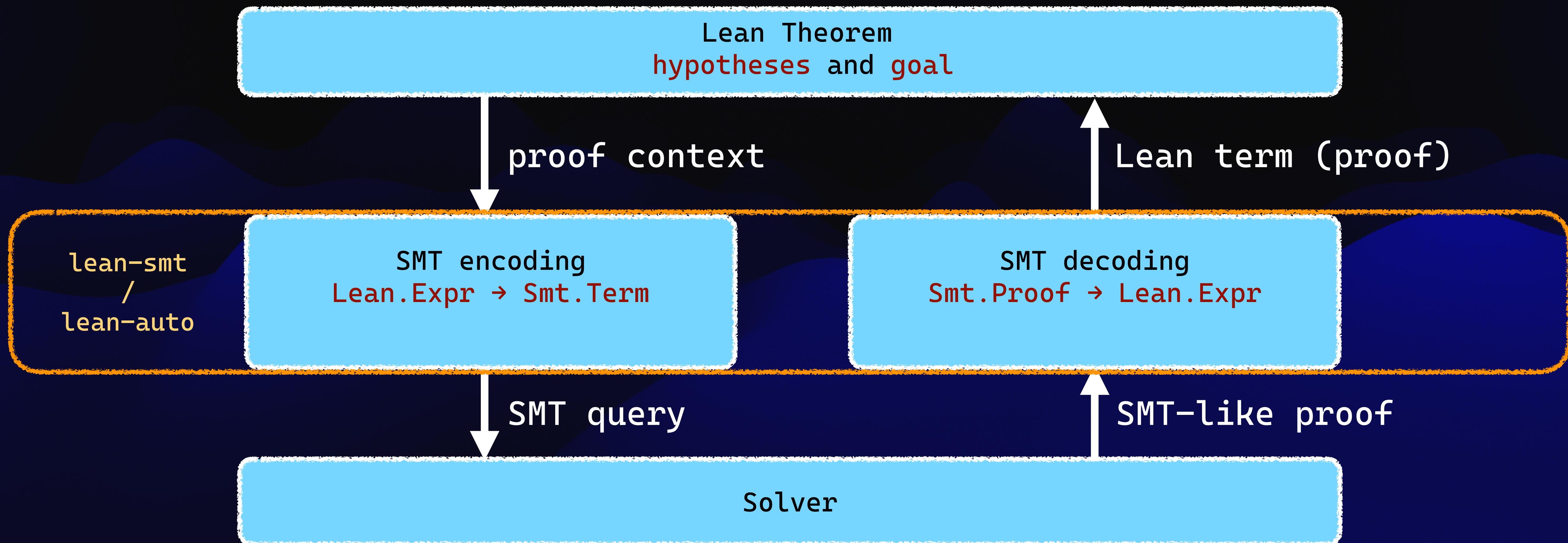
## CVC5 C++ API



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# SMT-based theorem proving



# The **falsifiable?** tactic

A lean-auto-based **toy** tactic from cvc.lean:

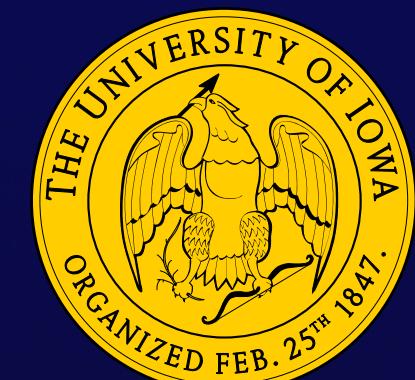
- on simple arithmetic theorems  
CvcTest/Tactic/Simple.lean
- on more complex fragments:  
CvcTest/Tactic/Fragments.lean

Make sure to also check the **smt** tactic from lean-smt:

- <https://github.com/ufmg-smite/lean-smt>



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# Thank you



## Links:

- **lean-cvc5**: <https://github.com/abdo08080/lean-cvc5>
- **cvc.lean**: <https://github.com/anzenlang/cvc.lean>
- **lean-smt**: <https://github.com/ufmg-smite/lean-smt>
- **lean-auto**: <https://github.com/leanprover-community/lean-auto>



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