Property-Based Testing for Spark SQL

Databricks Hackathon, Dec, 15
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Hey bricks,

Beijing just issued red alarm over air pollution for the first time. well... the air outside, which smells like smoke, makes me feel like Santa Claus climbing through a chimney... So, here's your X'mas present! Hope you like it :-)

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I  ENUMERATING TEST CASES

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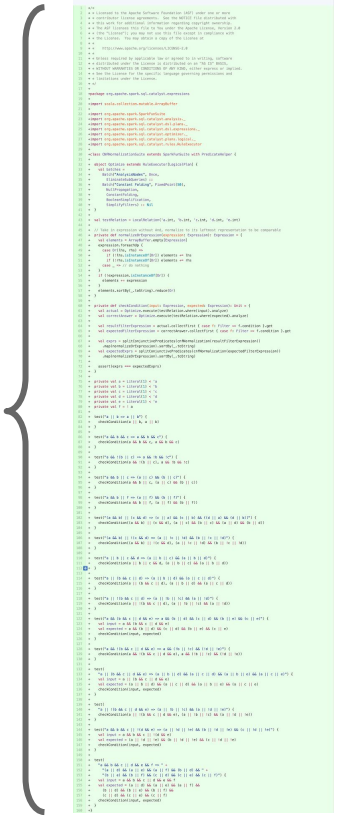
Don’t you?

PR #8200: CNF Conversion

25 lines of functional changes

160 lines of test cases, desperately enumerating all kinds of predicates…



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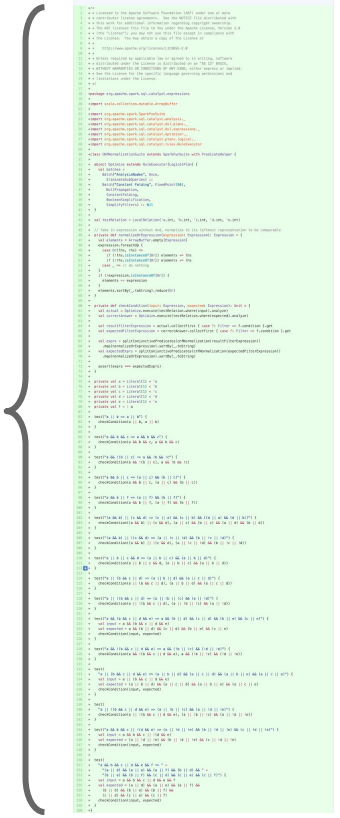
(Well, Apache licence takes 10%)



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ScalaCheck & Property-Based Testing to the Rescue!

ScalaCheck helps you...

Converting:

```
def add(x: Int, y: Int) = x + y

test("add") {
  assert(add(0, 0) === 0)
  assert(add(1, 0) === 1)
  assert(add(-1, 0) === -1)
  assert(add(42, -1) === 41)
  assert(add(Int.MaxValue, 1) === Int.MinValue)
  assert(add(Int.MinValue, -1) === Int.MaxValue)
  // ...
}
```

ScalaCheck helps you...

Into:

```
def add(x: Int, y: Int) = x + y

test("add") {
  check { (a: Int, b: Int) =>
   add(a, b) == a + b
  }
}
```

Property-Based Testing

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- Makes declarative statements about the output of your code based on the input
- These statements are verified for many different random inputs
- Special "interesting" inputs are also covered
  - `Int.MaxValue`
  - `Double.NaN`
  - `...`

Input Minimisation

When a test case fails, you probably don't want to look at a deeply nested, randomly generated spaghetti input schema / expression / logical plan.

Input Minimisation

ScalaCheck provides a Shrink API for shrinking large, complex random input data into smaller, simpler ones to help developers identifying corner cases.

What We Did...

This Hackathon Project

Is based on a minimized version of Catalyst, named Scraper. It was originally written by Cheng as an optimizing compiler of the Brainf**k language in less than 300 loc for illustrating the power of Catalyst in a local conference held in China early this year.

Now it's used as a Catalyst playground for polishing and prototyping all kinds of ideas.

This Hackathon Project

- Implements a prototype of property-based testing facilities for Spark SQL using ScalaCheck
  - Provides ScalaCheck generators for
    - random SQL data types
    - random SQL values
    - random type checked SQL expressions
    - random resolved logical query plans

This Hackathon Project

- Implements ScalaCheck Shrink API for expressions
  - Shrink support for logical plans is on the way!

This Hackathon Project

- Brings a bonus
  - A set of concise, flexible, and declarative API for query plan and expression type checking

CNFConversion Test Revisited

```
testRule(CNFConversion, FixedPoint.Unlimited) { optimizer =>
  implicit val arbPredicate =
    Arbitrary(genPredicate(TupleType.empty.toAttributes))

  check { predicate: Expression =>
    val optimizedPlan = optimizer(SingleRowRelation filter predicate)
    val conditions = optimizedPlan.collect {
      case _ Filter condition => splitConjunction(condition)
    }.flatten

    conditions.forall {
      _.collect { case _ And _ => () }.isEmpty
    }
  }
}
```

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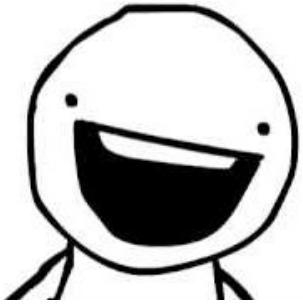
```

Look ma!
No enumerating!



What If Things Go Wrong?

Let's break rule `CNFConversion` by removing a case branch, so that "Or"s with an "And" as its right branch fail the test:

```
object CNFConversion extends Rule[LogicalPlan] {
  override def apply(tree: LogicalPlan): LogicalPlan = tree transformDown {
    case plan: Filter =>
      plan transformExpressionsDown {
        case Not(lhs Or rhs)                => !lhs && !rhs
        case Not(lhs And rhs)               => !lhs || !rhs
        case (innerLhs And innerRhs) Or rhs => (innerLhs || rhs) && (innerRhs || rhs)
     // case lhs Or (innerLhs And innerRhs) => (innerLhs || lhs) && (innerRhs || lhs)
      }
  }
}
```

What If Things Go Wrong?

Expression minimisation works, and gives exactly the simplest corner case after 13 shrinks!

```
[info] - BadCNFConversion *** FAILED ***
[info]   GeneratorDrivenPropertyCheckFailedException was thrown during property evaluation.
[info]    (OptimizerSuite.scala:78)
[info]     Falsified after 1 successful property evaluations.
[info]     Location: (OptimizerSuite.scala:78)
[info]     Occurred when passed generated values (
[info]       arg0 =
[info]   Or
[info]   ├─ false: boolean
[info]   └─ And
[info]     ├─ false: boolean
[info]     └─ false: boolean // 13 shrinks
[info]     )
```

Potentials

- Property-based testing
  - Easier, finer grained testing for
    - expressions
    - analyzer
    - query optimizer
    - query planner
  - Potentially faster test speed since we can test in finer grain without issuing Spark jobs all the time
  - Better test coverage (well, if we ever measure it)

Potentials

- Random query generator
  - The one Impala brings is great, but it has too many moving parts, and doesn't shrink inputs when things go wrong
  - Generators for logical plans and SQL values can be building blocks for an embedded random query generator for Spark SQL

Potentials

- The new type check API
  - Should be able to significantly simplify existing type casting and type checking rules in Spark SQL analyzer
  - SQL linting
    - (Hey, there are strings implicitly casted into doubles, which can be dangerous!)

Follow-ups

- Porting to Catalyst
- Logical plan to SQL translation for building random query generator (and can be useful for fully implementing native view)
- Logical plan minimisation
- Enrich generators and shrinkers for
  - Aggregations
  - Window functions
  - ……

References

- Scraper
- ScalaCheck together with user guide
- Our poor example CNFConversion pull request
- Just in case you are not familiar with CNF
- Initial discussion about the type check API

Thanks!

No Q & A this time