SparkFuzz: Searching Correctness Regressions in Modern Query Engines

Bogdan Ghit, **Nicolas Poggi**, Josh Rosen, Reynold Xin, and Peter Boncz*

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Introduction

Apache Spark

Fast and expressive data processing engine

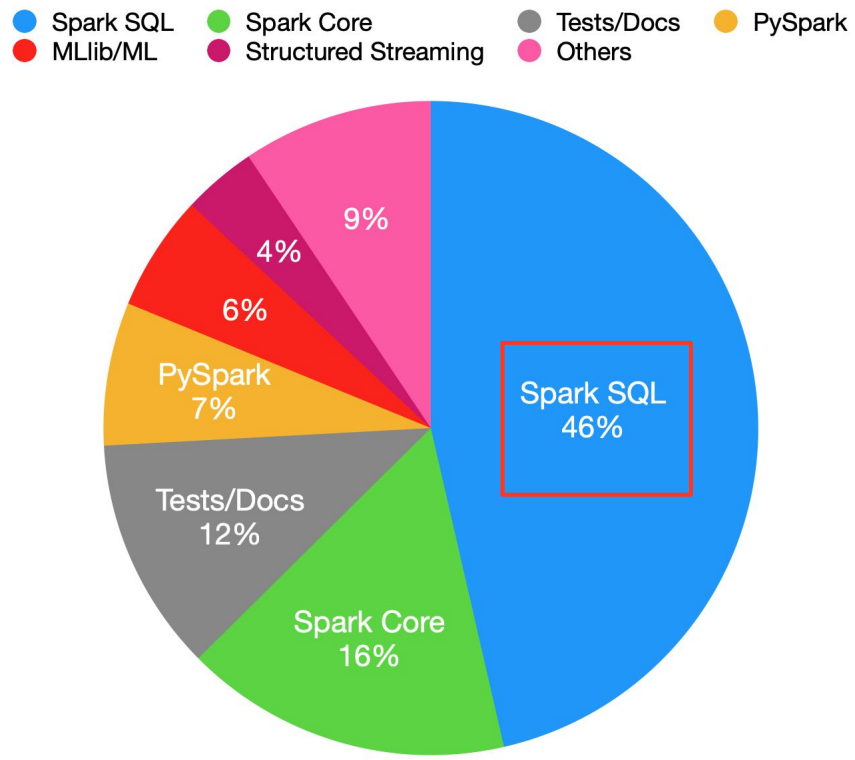
- distributed computing
- rich APIs
  - including SQL
- large community

Started at UC Berkeley in 2009

- 2010 - open sourced
- 2014 - top level project
- 2020 - v3 released (10 years!)

June 2002 v 3.0.0 released

3500+ resolved tickets



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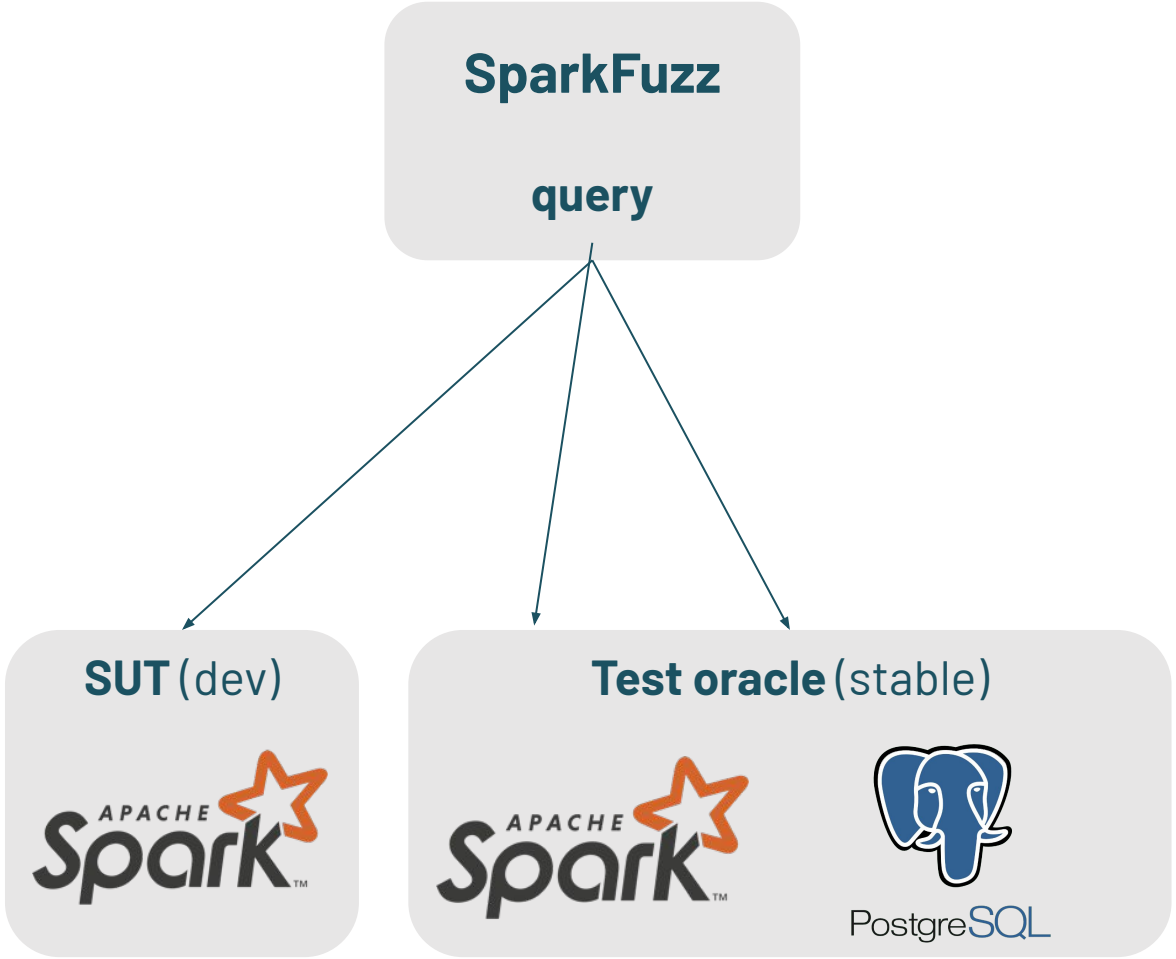
SparkFuzz proposal

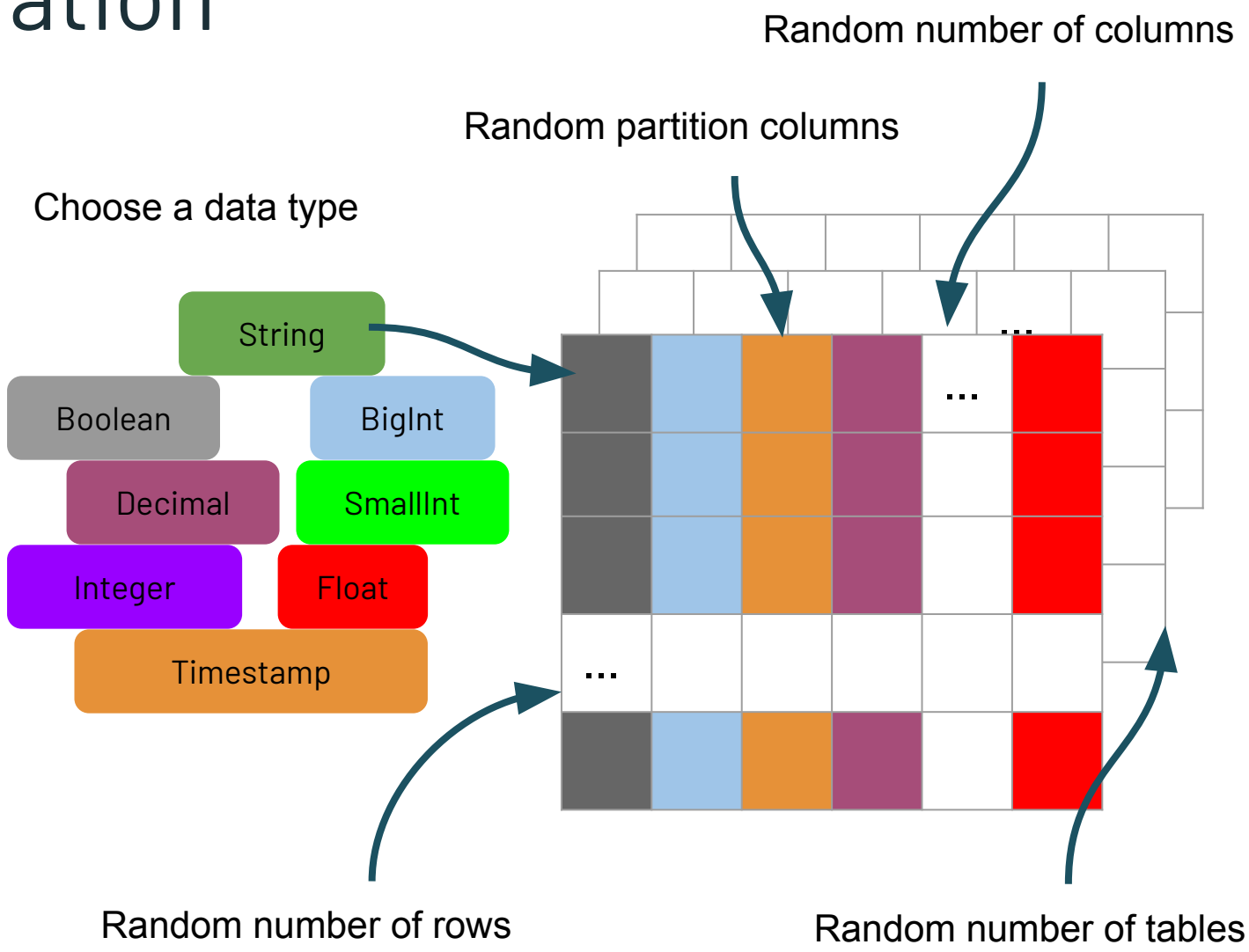
1. Leverage fuzz testing techniques
   a. to complement SQL testing
   b. automate bug discovery
2. Design of a toolkit for SQL engines
   a. model for randomized
      i. DDL, data, and queries
   b. A runner and evaluator
3. Applicability of coverage metrics
   a. as test stop gaps
   b. reducing time (and costs)
   c. enabling more testing dimensions



DDL and data generation

Automated dataset generation

- by randomly sampling
  - supported data types
  - parameter ranges
- Producing valid schemas
- Populating datasets



Recursive query model w/ a probabilistic profile

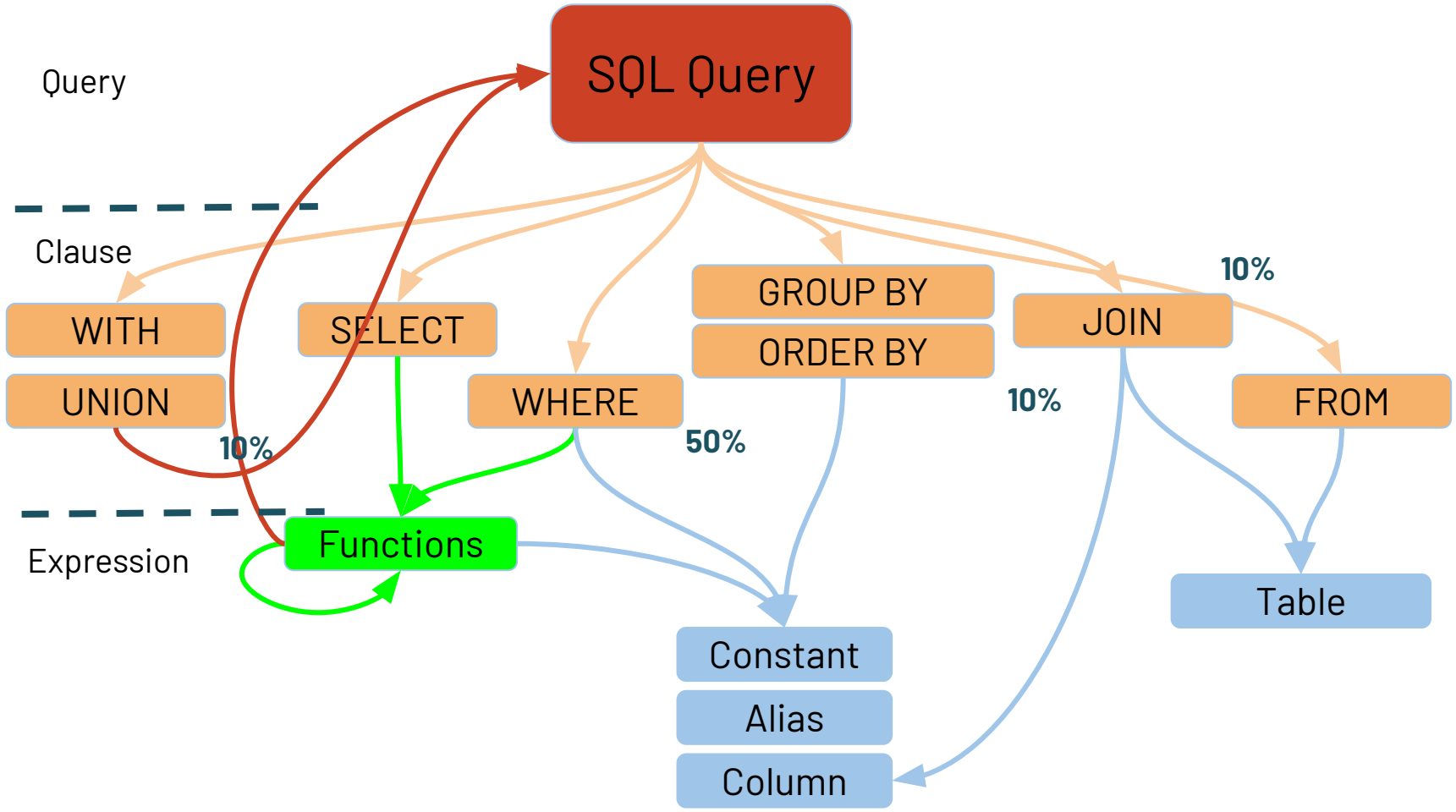
Operators and features annotated with:

Independent weights

- Optional clauses

Inter-dependent weights

- Join types
- Select functions



Query and regression example

Query produced in a small dataset with 2 tables of 5x5 size

```
SELECT COALESCE(t2.smallint_col_3, t1.smallint_col_3, t2.smallint_col_3) AS int_col,
      IF(NULL, VARIANCE(COALESCE(t2.smallint_col_3, t1.smallint_col_3, t2.smallint_col_3)),
      COALESCE(t2.smallint_col_3, t1.smallint_col_3, t2.smallint_col_3)) AS int_col_1,
      STDDEV(t2.double_col_2) AS float_col,
      COALESCE(MIN((t1.smallint_col_3) - (COALESCE(t2.smallint_col_3, t1.smallint_col_3,
      t2.smallint_col_3))), COALESCE(t2.smallint_col_3, t1.smallint_col_3,
t2.smallint_col_3),
      COALESCE(t2.smallint_col_3, t1.smallint_col_3, t2.smallint_col_3)) AS int_col_2
FROM table_4 t1
INNER JOIN table_4 t2 ON (t2.timestamp_col_7) = (t1.timestamp_col_7)
WHERE (t1.smallint_col_3) IN (CAST('0.04' AS DECIMAL(10,10)), t1.smallint_col_3)
GROUP BY COALESCE(t2.smallint_col_3, t1.smallint_col_3, t2.smallint_col_3)
```

- Within 10 queries, this query triggered an exception
- Related to COALESCE flattening

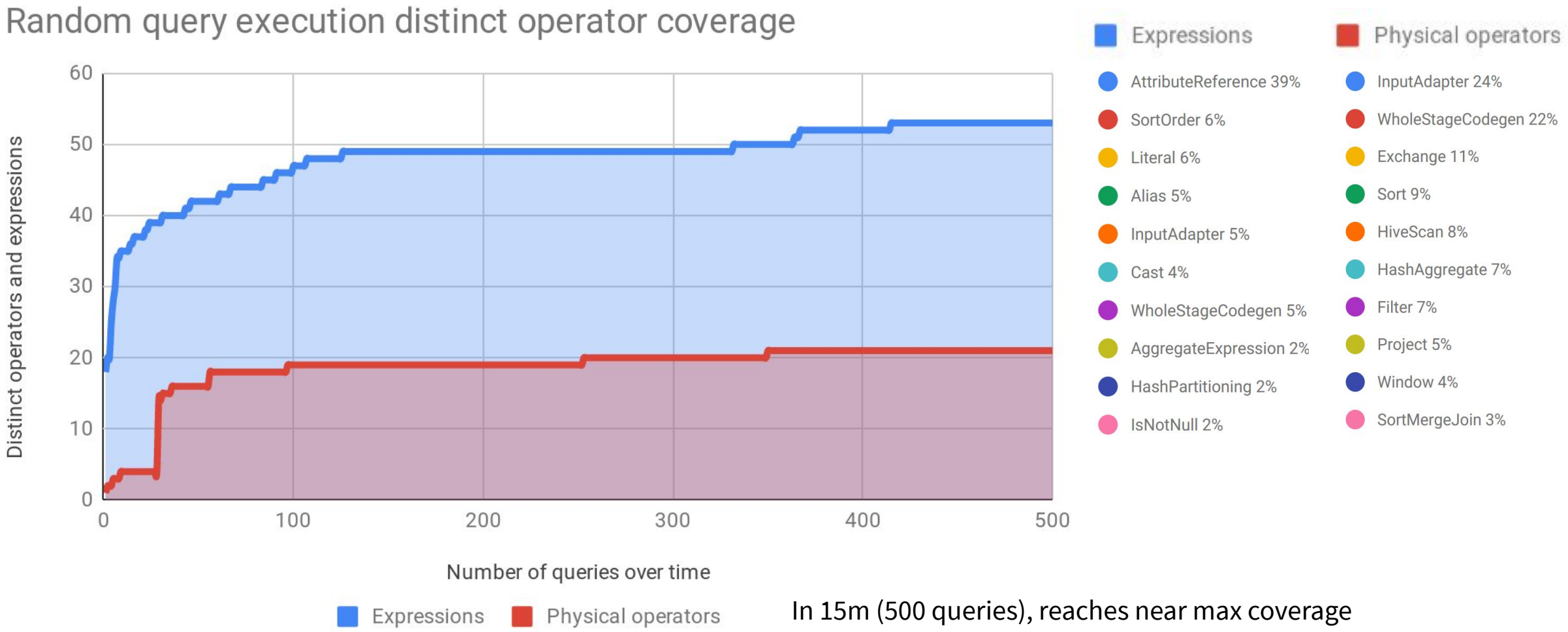
Correctness regression example [SPARK-16633]

Using constant input values breaks the the **LEAD** function

```
SELECT (t1.decimal0803_col_3) / (t1.decimal0803_col_3) AS decimal_col,
        CAST(696 AS STRING) AS char_col, t1.decimal0803_col_3,
       (COALESCE(CAST('0.02' AS DECIMAL(10,10)),
                 CAST('0.47' AS DECIMAL(10,10)),
                 CAST('-0.53' AS DECIMAL(10,10)))) +
       (LEAD(-65, 4) OVER (ORDER BY (t1.decimal0803_col_3) / (t1.decimal0803_col_3),
                 CAST(696 AS STRING))) AS decimal_col_1,
                 CAST(-349 AS STRING) AS char_col_1
FROM table_16 t1
WHERE (943) > (889)
```

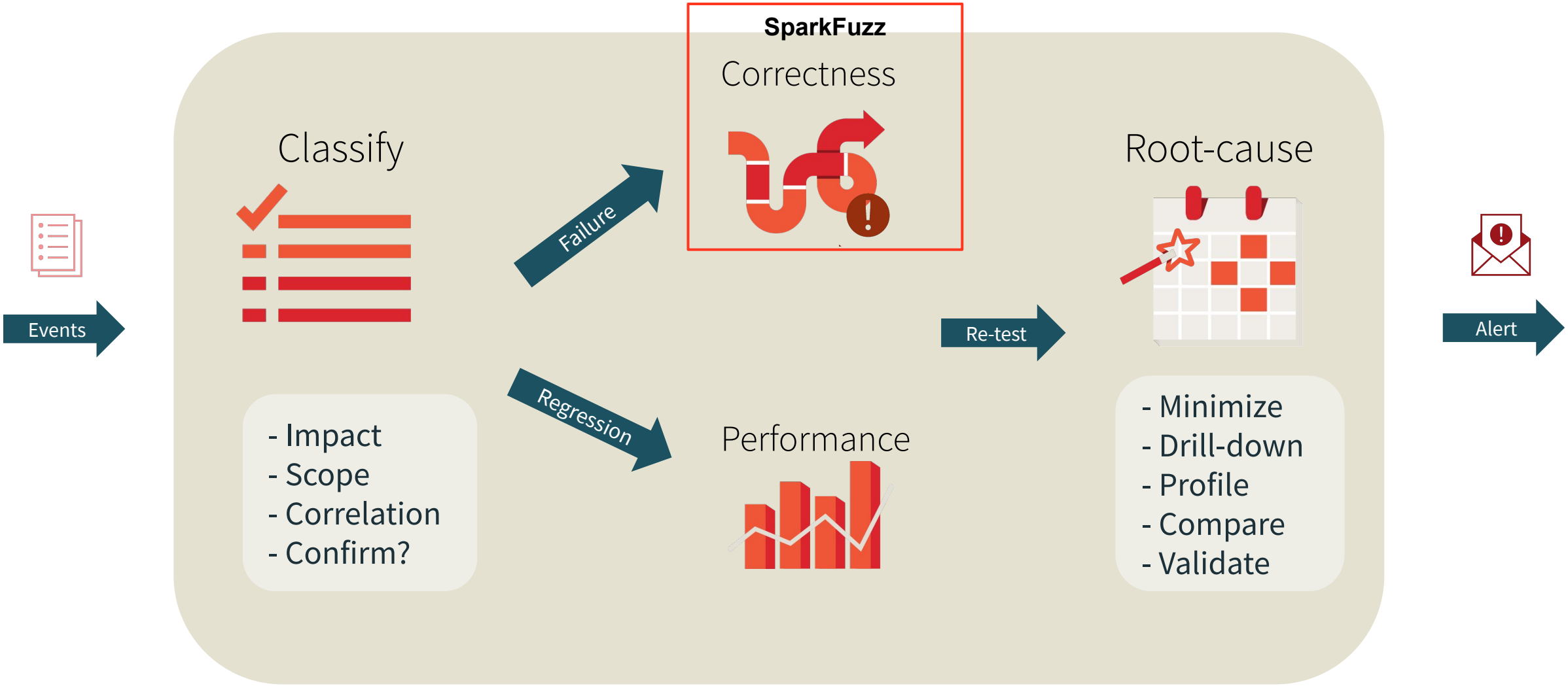
- Spark [1.0, 696, -871.81, **-64.98**, -349]
- PostgreSQL [1.0, 696, -871.81, **NULL**, -349]

Query operator coverage analysis



In 15m (500 queries), reaches near max coverage

Continuous Integration pipeline



Conclusion and future work

- Prevented SQL correctness errors reaching production
  - complementing the testing practices
- Runtime operator coverage metrics found applicable
  - For testing code changes rapidly
  - With a degree of coverage
- Future work
  - Improve the metric coverage to include operator chaining
  - Update the model generation to use Spark AST grammar directly

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Thanks, questions?

Bogdan Ghit, Nicolas Poggi, Josh Rosen, Reynold Xin, and Peter Boncz

Feedback: Nicolas.Poggi@databricks.com

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