Airport for DuckDB:
Letting DuckDB take Apache Arrow Flights

Rusty Conover - rusty@conover.me - DuckCon #6, Amsterdam, 2025-01-31

DuckDB Extensions I’ve created

- `Crypto` - Cryptographic hash functions
- `Datasketches` - Probabilistic data structures
- `Evalexpr_rhai` - Embedded scripting language
- `Fuzzycomplete` - Alternative autocompletion in CLI
- `Lindel` - Linearization (Morton/Hilbert curves)
- `Shellfs` - Subprocess I/O

Imagine a world where…

DuckDB makes tabular data access effortless and universal.

Any data, anywhere, on all systems.

All via SQL.

What is the Airport Extension?

An explanation by analogy.

Airports let you go to far away places
Flying is quick and efficient
You can bring things back
You can leave things there

What is the Airport Extension?

An explanation by analogy.

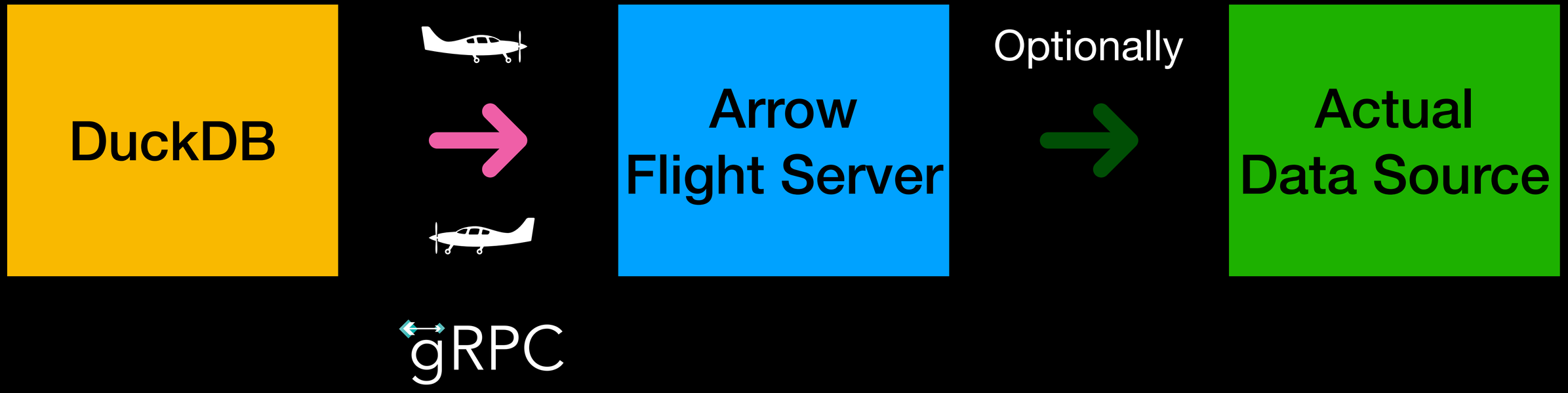
Airports let you go to far away places	Remote Servers and Systems
Flying is quick and efficient	Uses Apache Arrow Flight
You can bring things back	SELECT statements
You can leave things there	INSERT, UPDATE, DELETE…

Where can I fly to?

Anywhere sunny and somewhat tabular.

- “Lakehouse” Formats - Iceberg, Delta Lake, Vortex, Hudi, LanceDB, Nimble
- NoSQL - Redis, DynamoDB, MongoDB, Cassandra, AirTable
- Graph Databases - Kuzu, Neptune, Neo4j
- ⭐DuckDB instances⭐ on other machines
- Spark - Spark Connect
- DataBricks - Delta Sharing
- REST APIs: Stripe, Shopify, Github
- Event Busses and Queues: Kafka, WarpStream, SQS, RabbitMQ
- Old School Databases: LDAP, DNS, LMDB
- Other SQL Servers: SQL Server, Oracle, SQLite, Limbo
- Cloud Management: AWS, Google Cloud
- Management Services: Kubernetes, SNMP, Routing Tables
- Legacy Systems: Of course

How does Arrow Flight Work



Why did I create the Airport extension

Benefits

- Less code for new “extensions”.
- Leverage programming language ecosystems (PyPi, Crates)
- Runs outside of DuckDB
  - Complexity contained, Responsibility is clear, No crashes
  - Access distributed hardware and resources
- Simplifies the build, test, distribute loop
- Can offer data-as-a-service and function-as-a-service

Ready for some demos?

Delta Lake with Write Support

AutoGluon: Machine Learning with only SQL

Maybe: Geocoding and Weather

Delta Lake With Write Support


```
ATTACH 'deltalake' (
   TYPE AIRPORT,
   location ‘grpc://localhost:50312/'
);
CREATE SCHEMA deltalake.test1;
CREATE TABLE deltalake.test1.people (
     name VARCHAR,
     love_of_duckdb INT,
     tags VARCHAR[]
);
```

Delta Lake With Write Support


```
INSERT INTO deltalake.test1.people values
('rusty', 5, ['airport', 'datasketches']),
('sam', 10, ['deltalake', ‘iceberg']);

SELECT * FROM deltalake.test1.people;
          name = rusty
love_of_duckdb = 5
          tags = [airport, datasketches]

          name = sam
love_of_duckdb = 10
          tags = [deltalake, iceberg]
```

Delta Lake With Write Support

Yes this could be S3, Azure, GCS, R2…

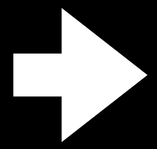

```
$ ls -lR
total 8
drwxr-xr-x  4 rusty  staff   128 Jan 30 23:13 _delta_log
-rw-r--r--  1 rusty  staff  1225 Jan 30 23:13 part-00001-82e3eb4e-
b4e1-4344-ad1d-4c9183c918e8-c000.snappy.parquet

./_delta_log:
total 16
-rw-r--r--  1 rusty  staff  1586 Jan 30 23:12 00000000000000000000.json
-rw-r--r--  1 rusty  staff   737 Jan 30 23:13 00000000000000000001.json
```

Delta Lake With Write Support

How it works

APACHE ARROW

DuckDB



Arrow Flight Server

`Python delta-rs`

Predicate Pushdown

DuckDB Catalog Integration

In the interest of time, I'm skipping over:

- Time Travel
- Row Change Tracking
- Run jobs outside of DataBricks
- Compaction / Partitions
- Unity Catalog Integration
- dbt

How does Arrow Flight Work

APACHE ARROW

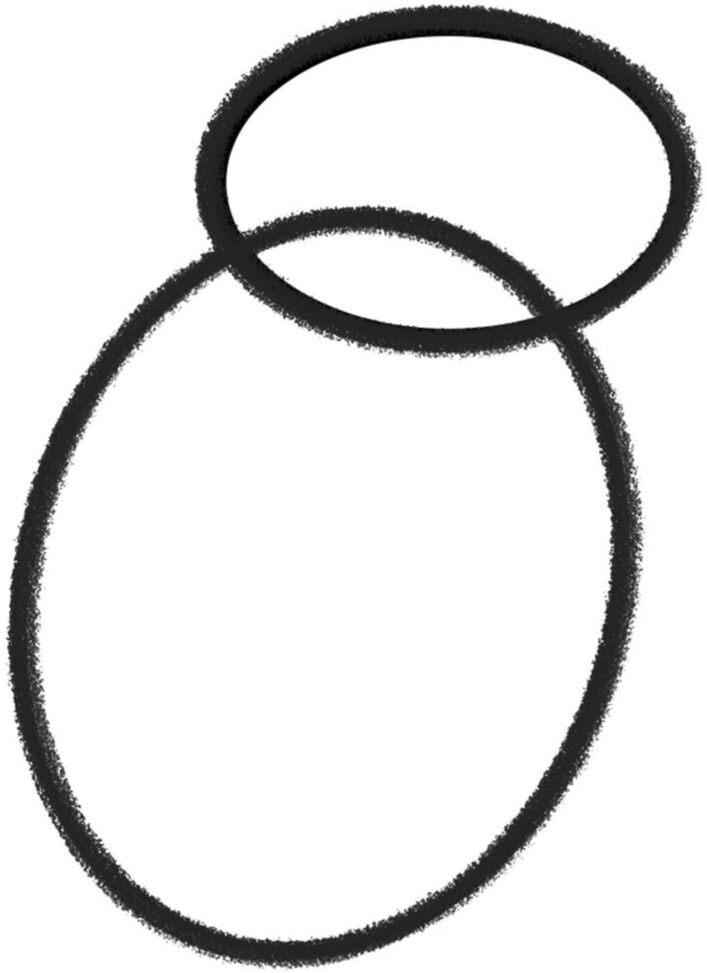
DuckDB

Process Boundary

Arrow Flight Server

python™

- Can be written in Java, Python, Rust, C#, C++
- Runs out of process with DuckDB, no need to relink/rebuild/distribute dependencies.
- ⏰ Skipping details due to time.



Step 1: Draw some circles

Step 2: Draw the rest of the owl!

AutoGluon

“Fast and Accurate ML in 3 Lines of Code”

- Build a ML Model with A Few SELECT Statements.
- Tabular Prediction
  - Binary/Multiclass Classification, Regression, Quantile Prediction
- Time Series Prediction
- No need to get into a Python notebook

Hacker News Votes Prediction

AutoGluon

```
ATTACH 'autogluon' (TYPE AIRPORT, location
‘grpc://localhost:50312/');

CREATE SCHEMA autogluon.p1;

CREATE TABLE
 autogluon.p1.hn_stories as
  SELECT
    title,
    to_timestamp(time) as post_time,
    score::float as score
  FROM ‘hacker-news-stories.parquet’;
```

Hacker News Votes Prediction

AutoGluon

Create the model, “fit the predictor”…

```
SELECT * FROM
 autogluon.p1.predictor_fit(
   ‘hn_votes’,    – model name
   ‘hn_stories’, - training data
   ‘score’,         - target column
   problem_type=‘regression’,
   time_limit=200,
   presets=‘high_quality’)
```

Hacker News Votes Prediction

AutoGluon

Create some example data for the model to use.

```
CREATE TABLE example_headlines (title text);

INSERT INTO example_headlines values
    ('DuckDB 1.2.0'),
    ('Iceberg versus Delta Lake, tales from the
    format war'),
    ('SQL tips and tricks'),
    ('AI will replace all CS graduates'),
    ('Spaces are better than tabs, prove me wrong');
```

Hacker News Votes Prediction

AutoGluon

Calling the model to make predictions

```
SELECT title, prediction
FROM
autogluon.p1.predictor_predict_rows(
  'hn_votes',          - model name
  (SELECT title,       - model input
   now() as post_time
   FROM example_headlines));
```

Hacker News Votes Prediction

AutoGluon

Prediction Results

```
     title = DuckDB 1.2.0
prediction = 34.16758

     title = Iceberg versus Delta Lake, tales from the format war
prediction = 25.366014

     title = SQL tips and tricks
prediction = 16.140633

     title = AI will replace all CS graduates
prediction = 13.036682

     title = Spaces are better than tabs, prove me wrong
prediction = 38.696304
```

Hacker News Votes Prediction

AutoGluon

Testing HN post titles

```
SELECT * FROM
    autogluon.p1.predictor_predict_rows('hn_votes',
    (SELECT
      'Airport Extension for DuckDB using Arrow Flight' as
    title,
      now() as post_time
    ));

     title = Airport Extension for DuckDB using Arrow Flight
 post_time = 2025-01-31 08:06:40.764+00
prediction = 12.30423
```

Geocoding and Weather (Bonus Content)

```
ATTACH ‘geocoder' (
  TYPE AIRPORT, location ‘grpc://localhost:50212/'
);

SELECT geocoder.usa.geocode_address(
    '1600 Pennsylvania Ave, Washington, DC'
) as result;

result = {
    'latitude': 38.879389288728,
    'longitude': -76.982767739978
}
```

Geocoding and Weather

```
SELECT address,
unnest(
    geocoder.weather.current(
        geocoder.usa.geocode_address(address)
    )
) FROM places;

       address = 1023 Lenox Ave, Miami Beach, FL 33139
     timestamp = 2025-01-31 01:30:00
   temperature = 21.1
    wind_speed = 20.8
wind_direction = 118
    conditions = Mainly clear
```

Distributed Scalar UDFs

```
{
    "flight_name": "geocoder/usa/uppercase",
    "comment": "upper case a string",
    "input_schema": pa.schema(
        [
            pa.field("input", pa.string()),
        ]
    ),
    # Scalar UDFs have a single field
    "output_schema": pa.schema([
        pa.field("result", pa.string())
    ]),
    "process": uppercase_string,
},
```

Distributed Scalar UDFs

```
def uppercase_string(input: pa.Table) -> list[dict[str, Any]]:
    return [
      {"result": row["input"].upper()}
      for row in input.to_pylist()
    ]
```

```
SELECT geocoder.usa.uppercase('hello ' || range) as r
from ids limit 3;
     r = HELLO 0
     r = HELLO 1
     r = HELLO 2
```

What Airport Can Do?

Feature List

Basics	`airport_list_flights()` `airport_take_flights()`
Catalog Integration, Schemas and Tables	`ATTACH, CREATE SCHEMA, CREATE TABLE` `INSERT, UPDATE, DELETE, SELECT`
Scalar User Defined Functions	`SELECT function(value) from source;`
Table In/Out Functions	`SELECT * from airport_function('Name',` `(SELECT * from source));`
Authentication / Secrets Manager	`CREATE SECRET`

When will this be ready?

Ship it!

- Will be a community extension. Needs DuckDB >=1.2
- MIT Licensed on GitHub.
- https://github.com/Query-Farm/duckdb-airport-extension
- Please ⭐ the repo.
- Send me your questions: rusty@conover.me, follow me on LinkedIn for updates.
- Join the DuckDB Discord
- What is “Query Farm”?
  A forthcoming collection of Airport Flight Servers for data sources.

Questions and hopefully, answers

Submit your questions here:

https://app.sli.do/event/tiAGnGKijPD64BgSxHxv2U