PRQL

Pipelined Relational Query Language

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```
from albums
filter album_id > 100
sort albums.title
take 10
join artists (==artist_id)
select {
    albums.album_id,
    albums.title,
    f"Artist name: {artist.name}",
}
```

Why?

There are transition costs!

Overview

Flaws of SQL

Language for relations

Compiling queries

PRQL, the project

A deef dive into

Flaws of SQL

Origins of the relational model

1970, Edgar F. Codd: abstraction over data storage

→ Tuple relational calculus

1974, Donald D. Chamberlin & Raymond F. Boyce: SEQUEL

→ Not a “proper” programming language

Not really composable

```
SELECT album_id, COUNT(*) AS track_count
FROM tracks GROUP BY album_id
```

Not really composable

```
SELECT i.album_id, i.track_count, a.artist_id
FROM (
  SELECT album_id, COUNT(*) AS track_count
  FROM tracks GROUP BY album_id
) AS i
JOIN albums a USING (album_id)
```

Patched syntax

```
SELECT
  SUM(total)
FROM
  invoices
```

Patched syntax

```
SELECT
  total / SUM(total) OVER () AS normalized_total
FROM
  invoices
```

Patched syntax

```
SELECT DISTINCT name
FROM invoices
```

Patched syntax

```
SELECT EVALUATE TYPE-EMPLOYEE
  WHEN "F"
    MOVE "FULL TIME" TO EMP-TYPE-PR
  WHEN "P"
    MOVE "PART TIME" TO EMP-TYPE-PR
  WHEN "C"
    MOVE "CONSULTANT" TO EMP-TYPE-PR
  WHEN OTHER
    MOVE "INVALID" TO EMP-TYPE-PR
```

Patched syntax

Too much syntax

... but also ...

Not enough syntax

Name resolution

```sql
SELECT title AS title_alias
FROM albums
```

Name resolution

```
SELECT title AS title_alias
FROM albums
WHERE title_alias LIKE 'Do I Wanna %'
GROUP BY title_alias
ORDER BY title_alias
```

Name resolution

More rules:

– ORDER BY positionals

– Correlated subqueries

– LATERAL

Relations vs scalars

```
SELECT * FROM table

SELECT count(*) FROM table
```

Relations vs scalars

```
SELECT emp_id FROM emp WHERE role = 'manager'
```

Relations vs scalars

```
SELECT *
FROM emp
WHERE emp_id = (
    SELECT emp_id FROM emp WHERE role = 'manager'
)
```

Relations cannot be ordered

```
SELECT * FROM albums ORDER BY title
```

Relations cannot be ordered

```
SELECT
  *,
  ... AS my_col
FROM (
    SELECT * FROM albums ORDER BY title
) inner
```

Relations cannot be ordered

```
SELECT
  *,
  ROW_NUMBER()
    OVER (ORDER BY artist_id) AS my_col
FROM (
    SELECT * FROM albums ORDER BY title
) inner
```

Relations cannot be ordered

SELECT returns an **ordered set**

FROM pulls-in a **set**

Relations cannot be ordered

```
SELECT
  *,
  ... AS my_col
FROM (
    SELECT *
    FROM albums
) inner
ORDER BY title
```

Relations cannot be ordered

```
SELECT
  *,
  ... AS my_col
FROM (
    SELECT * FROM albums ORDER BY title LIMIT 10
) inner
ORDER BY title
```

Identity of aggregation

```
SELECT SUM(cost) FROM expenses WHERE FALSE
```

Two possible behaviors: NULL or 0

Both valid

Identity of aggregation

“Every marble in this bag is black”
... but the bag is empty.

Ancient greeks say FALSE

Modern logic says TRUE

SQL says NULL

Identity of aggregation

Homomorphism of addition

```
SUM([1]) + SUM([4, 5]) = SUM([1, 4, 5])

                 1 + 9 = 10
```

Identity of aggregation

```
SUM([1]) + SUM([]) = SUM([1])

       1 +    ?    = 1

        -> SUM([]) = 0
```

identity of addition

Identity of aggregation

```
COUNT([])      = 0
ARRAY_AGG([])  = []
SUM([])        = 0
ANY([])        = false
EVERY([])      = true
STRING_AGG([]) = ''
```

Dialects

Differences in:

- syntax (TOP vs LIMIT)

- available functions

- available data types

Dialects

A class of languages

There is a standard

Slight deviations

Dialects

Different:

- priorities

- backward compatibility guarantees

- implementation limitations

Dialects

No clear & robust specification

Compilers could:

- adapt query to target database

- produce error early

Design of a new

Language for relations

Tuple relational calculus

Relation $\sim$ a set of tuples

$$\pi_{track\_id,name,title}(R)$$

$$\sigma_{track\_id=5}(R)$$

$$R * S$$

Data model

Basic data types

`bool`, `int`, `float`, `str`

Data model

Tuples

```
{my_int = 5, 4.2, my_bool = true}
```

- named fields
- different types
- static number of fields

Data model

Arrays

```
[1, 2, 10, -3]
```

- unnamed items
- items have the same type
- dynamic number of items

Data model

Relation $:=$ an array of tuples

```
[
    {my_int =  5, 4.2, my_bool = true},
    {my_int = -2, 6.1, my_bool = false},
    {my_int = 12, 3.0, my_bool = false},
]
```

Declarations

```
let a = 5

let b = a + 1
```

Functions

```
let add_one = x -> x + 1

let add = x y -> x + y
```

Functions

```
let five = (add_one 4)

let six = (add 4 2)
```

Functions

```
let seven = (5 | add_one | add_one)

let seven = (
    5
    add_one
    add_one
)
```

Transforms

Transform $:=$ a function on relations

```
let invoices = ...

let main = (filter (total > 10) invoices)
```

Transforms

```
let invoices = ...

let main = (invoices | filter (total > 10))
```

Transforms

```
let invoices = ...

let main = (
    invoices
    filter (total > 10)
)
```

Transforms

```
let invoices = ...

invoices
filter (total > 10)
```

Transforms

```
from invoices
filter (total > 10)
```

Transforms

```
from invoices
filter total > 10
```

Top to bottom

```
from albums
filter album_id > 100
sort albums.title
```

Top to bottom

```
from albums
filter album_id > 100
sort albums.title
take 10
```

Top to bottom

```
from albums
filter album_id > 100
sort albums.title
take 10
join artists (==artist_id)
```

Top to bottom

```
from albums
filter album_id > 100
sort albums.title
take 10
join artists (albums.artist_id == artists.artist_id)
```

Top to bottom

```
from albums
filter album_id > 100
sort albums.title
take 10
join artists (==artist_id)
select {
    albums.album_id,
    albums.title,
    f"Artist name: {artist.name}",
}
```

Top to bottom

- Convenient for exploration

- Lazy evaluation

- Extract a variable

- Extract a function

Top to bottom

```
let take_cheapest = n rel -> (
    rel
    sort unit_price
    take n
)

from tracks
take_cheapest 5
```

Orthogonal

```
from expenses
filter dept == "Sales"
aggregate {total = sum cost}
filter total > 100.00
```

WHERE ↦ filter HAVING ↦ filter

Orthogonal

Transform invariants:

- `filter` will not change columns

- `derive` & `select` will not change number of rows

- `aggregate` will produce exactly one row

Grouping

```
from expenses
aggregate {total = sum cost}
```

```
[
    {total = 431.22},
]
```

Grouping

```
from expenses
group dept (
    aggregate {total = sum cost}
)
```

```
[
  {dept = "Sales",      total = 331.00},
  {dept = "Accounting", total = 100.22},
]
```

Grouping

```
from expenses
group dept (
    take 1
)
```

```
[
  {dept = "Sales",      id = 33, cost =  5.30},
  {dept = "Accounting", id = 45, cost = 12.22},
]
```

Grouping

```
from expenses
group dept (
    sort {-cost}
    take 1
)
```

```
[
  {dept = "Sales",      id = 33, cost = 5.30},
  {dept = "Accounting", id = 16, cost = 1.22},
]
```

Grouping

```
from expenses
group expenses.* (
    take 1
)
```

Grouping

```
from expenses
group expenses.* (
    take 1
)
```

```
SELECT DISTINCT *
FROM expenses
```

Nulls

```
# PRQL
null == null  # true

my_col == null

-- SQL
my_col IS NULL
```

Micro-features

```
from employees
derive {
  age = @2023-01-31 - birth_date,
  full_name = f"{first_name} {last_name}",
  manager = reports_to ?? "No one",
#  is_fired = "No",
  salary = 1_000_000,
}
```

Challenges of

Compiling queries

SQL as a compilation target

How is this language executed?

✗ database interface

✓ a query language

The task of a query lanuage

Imagine a database without a query language.

```
SELECT * FROM albums
```

... and then transform in client code.

→ super slow

The task of a query lanuage

Extreme example:

```
SELECT COUNT(*)
FROM albums
WHERE title LIKE 'The %'
```

The task of a query lanuage

Processing should be close to data

- minimal data transfer

- parallelism

- vectorization

The task of a query lanuage

Databases are:

- execution platforms

- compilation targets

Analogous to amd64, JVM

Leaky abstractions

Database interface should be transparent

Currently, this is not the case:

- invalid SQL

- sub-optimal SQL

- runtime errors

PRQL, the project

– an opensource effort

The compiler and its IRs

prqlc: compiler from PRQL to SQL

targets: sql.postgres, sql.sqlite, sql.duckdb, sql.mysql, sql.clickhouse

bindings for C, Python, JS, Java, .NET, PHP

The compiler and its IRs

Don’t connect, infer

Fail early

```
Error:
   ╭─[:2:8]
   │
 2 │ select column_name = [track_id, name]
   ·        ───────────────┬───────────────
   ·                       ╰───────────────── unexpected assign to `column_name`
   ·
   · Help: move assign into the list: `[column_name = ...]`
───╯
```

Architecture

PRQL → PL → RQ → SQL

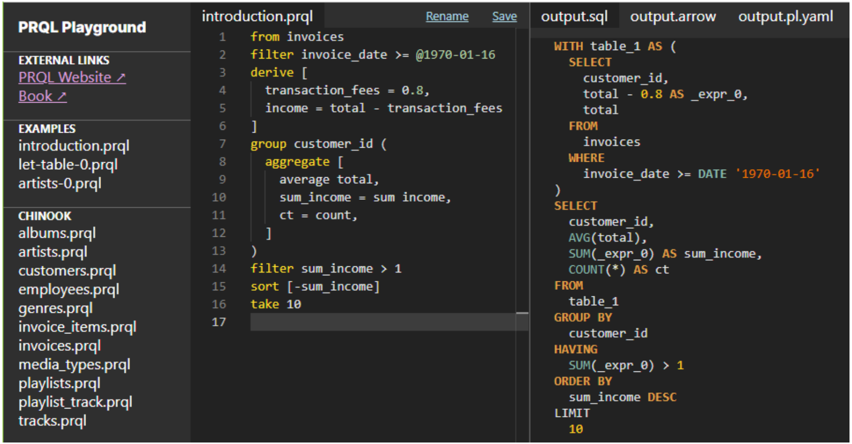
Licence

Apache

Open community

No plans to monetize

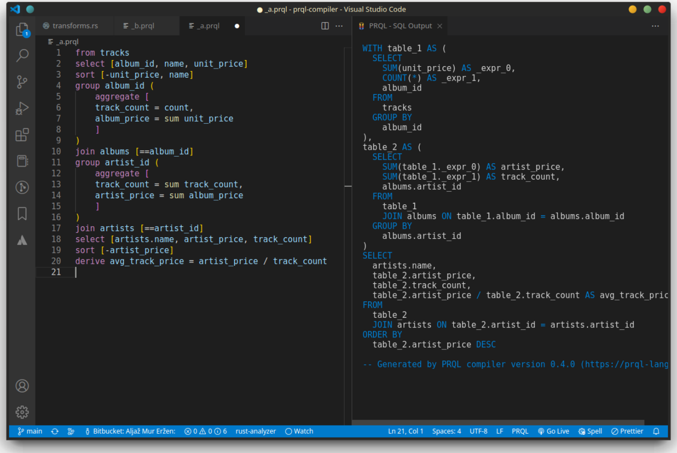
Check it out: playground



```
from invoices
filter invoice_date >= @1970-01-16
derive [
  transaction_fees = 0.8,
  income = total - transaction_fees
]
group customer_id (
  aggregate [
    average total,
    sum_income = sum income,
    ct = count,
  ]
)
filter sum_income > 1
sort [-sum_income]
take 10
```

```
WITH table_1 AS (
  SELECT
    customer_id,
    total - 0.8 AS _expr_0,
    total
  FROM
    invoices
  WHERE
    invoice_date >= DATE '1970-01-16'
)
SELECT
  customer_id,
  AVG(total),
  SUM(_expr_0) AS sum_income,
  COUNT(*) AS ct
FROM
  table_1
GROUP BY
  customer_id
HAVING
  SUM(_expr_0) > 1
ORDER BY
  sum_income DESC
LIMIT
  10
```

Check it out: VSCode extension



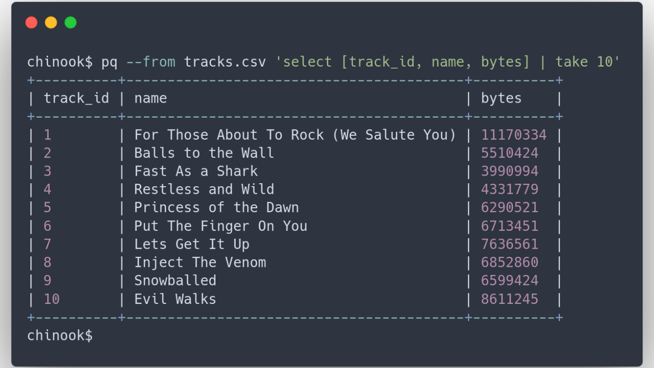
_a.prql

```
from tracks
select [album_id, name, unit_price]
sort [-unit_price, name]
group album_id (
    aggregate [
    track_count = count,
    album_price = sum unit_price
    ]
)
join albums [==album_id]
group artist_id (
    aggregate [
    track_count = sum track_count,
    artist_price = sum album_price
    ]
)
join artists [==artist_id]
select [artists.name, artist_price, track_count]
sort [-artist_price]
derive avg_track_price = artist_price / track_count
```

```
WITH table_1 AS (
  SELECT
    SUM(unit_price) AS _expr_0,
    COUNT(*) AS _expr_1,
    album_id
  FROM
    tracks
  GROUP BY
    album_id
),
table_2 AS (
  SELECT
    SUM(table_1._expr_0) AS artist_price,
    SUM(table_1._expr_1) AS track_count,
    albums.artist_id
  FROM
    table_1
    JOIN albums ON table_1.album_id = albums.album_id
  GROUP BY
    albums.artist_id
)
SELECT
  artists.name,
  table_2.artist_price,
  table_2.track_count,
  table_2.artist_price / table_2.track_count AS avg_track_pric
FROM
  table_2
  JOIN artists ON table_2.artist_id = artists.artist_id
ORDER BY
  table_2.artist_price DESC

-- Generated by PRQL compiler version 0.4.0 (https://prql-lang
```

Check it out: prql-query - pq



```
chinook$ pq --from tracks.csv 'select [track_id, name, bytes] | take 10'
+----------+-----------------------------------------+----------+
| track_id | name                                    | bytes    |
+----------+-----------------------------------------+----------+
| 1        | For Those About To Rock (We Salute You) | 11170334 |
| 2        | Balls to the Wall                       | 5510424  |
| 3        | Fast As a Shark                         | 3990994  |
| 4        | Restless and Wild                       | 4331779  |
| 5        | Princess of the Dawn                    | 6290521  |
| 6        | Put The Finger On You                   | 6713451  |
| 7        | Lets Get It Up                          | 7636561  |
| 8        | Inject The Venom                        | 6852860  |
| 9        | Snowballed                              | 6599424  |
| 10       | Evil Walks                              | 8611245  |
+----------+-----------------------------------------+----------+
chinook$
```

Check it out

```
pip install pyprql
install.packages("prqlr")
npm install prql
cargo add prql-compiler
```

https://prql-lang.org

https://github.com/PRQL/prql

https://discord.gg/TfyM755m