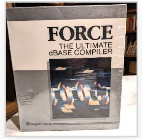
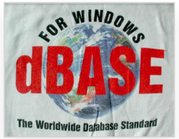
hi, i’m lloyd

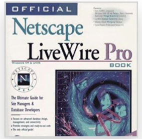
Encore!



1987 - Force



1992 - dBASE



1994 - LiveWire

2003 - LTool (perl)

2007 - LTool (python)

2009 - El Tool (php)

2012 - Looker

2020 - Malloy

Data is Rectangular and other Limiting Misconceptions

Operations within the Rectangle

filtering

group by / aggregate

projecting

windowing

Humans think in rectangular calculations

In SQL Joins, produce a new rectangle

In SQL joins produce a new rectangle.

FIRST: Joins tables expand rows to first produce a new rectangle

THEN: perform Rectangular operations up on the new rectangle.

orders

order_id	order_date	shipping_cost	user_id
1	2022-01-01	2	1
2	2022-01-01	3	2
3	2022-01-02	1	1
4	2022-01-02	23	3

orders

order_id	order_date	shipping_cost	user_id
1	2022-01-01	2	1
2	2022-01-01	3	2
3	2022-01-02	1	1
4	2022-01-02	23	3

order_items

item_id	order_id	item	price
1	1	Chocolate	2
2	1	Twizzler	1
3	2	Chocolate	2
4	2	M and M	1
5	3	Twizzler	1
6	4	Fudge	3
7	4	Skittles	1

Let’s measure two things, from sales...

total_shipping

total_revenue

total_shipping

```
SELECT
   sum(shipping_cost) AS total_shipping
FROM ‘orders.csv
```

total_shipping
8

total_revenue

```
SELECT
   sum(price) AS total_revenue
FROM ‘items.csv’;
```

total_revenue
11

total_shipping by date

```
SELECT
   order_date,
   sum(shipping_cost) AS total_shipping
FROM ‘orders.csv’
GROUP BY 1
ORDER BY 1
```

order_date	total_shipping
2022-01-01	5
2022-01-02	3

total_revenue by date

```
SELECT
   order_date,
   sum(price) AS total_revenue
FROM ‘orders.csv’ AS orders
JOIN ‘items.cvs’ AS items on
   orders.order_id = items.order_id
GROUP BY 1
ORDER BY 1
```

order_date	total_revenue
2022-01-01	6
2022-01-02	5

How does revenue relate to shipping?

order_date	total_revenue	total_shipping
2022-01-01	6	5
2022-01-02	5	3

```
SELECT
   orders.order_date,
   sum(items.price) AS total_revenue,
   sum(orders.shipping_cost) AS total_shipping
FROM ‘orders.csv’ AS orders
JOIN ‘items.cvs’ AS items ON orders.order_id = items.order_id
GROUP BY 1
ORDER BY 1
```

order_date	total_revenue	total_shipping
2022-01-01	6	10
2022-01-02	5	5

```
SELECT
   orders.order_date,
   sum(items.price) AS total_revenue,
   sum(orders.shipping_cost) AS total_shipping
FROM ‘orders.csv’ AS orders
JOIN ‘items.cvs’ AS items ON orders.order_id = items.order_id
GROUP BY 1
ORDER BY 1
```

order_date	total_revenue	total_shipping
2022-01-01	6	10
2022-01-02	5	5

WRONG!

```
SELECT *
FROM ‘orders.csv’ orders
LEFT JOIN ‘items.csv’ AS items ON orders.order_id = items.order_id
```

order_id	order_date	shipping_cost	user_id	item_id	order_id	item	price
1	2022-01-01	2	1	2	1	Twizzler	1
2	2022-01-01	3	2	4	2	M and M	1
3	2022-01-02	1	1	5	3	Twizzler	1
4	2022-01-02	2	3	7	4	Skittles	1
1	2022-01-02	2	1	1	1	Chocolate	2
2	2022-01-02	3	2	3	2	Chocolate	2
4	2022-01-02	2	3	6	4	Fudge	3

```
SELECT *
FROM 'orders.csv' orders
LEFT JOIN 'items.csv' AS items ON orders.order_id = items.order_id
```

order_id	order_date	shipping_cost	user_id	item_id	order_id	item	price
1	2022-01-01	2	1	2	1	Twizzler	1
2	2022-01-01	3	2	4	2	M and M	1
3	2022-01-02	1	1	5	3	Twizzler	1
4	2022-01-02	2	3	7	4	Skittles	1
1	2022-01-02	2	1	1	1	Chocolate	2
2	2022-01-02	3	2	3	2	Chocolate	2
4	2022-01-02	2	3	6	4	Fudge	3

Order rows are duplicated by the JOIN so computation is overstated.

```
SELECT *
FROM 'orders.csv' orders
LEFT JOIN 'items.csv' AS items ON orders.order_id = items.order_id
```

order_id	order_date	shipping_cost	user_id	item_id	order_id	item	price
1	2022-01-01	2	1	2	1	Twizzler	1
2	2022-01-01	3	2	4	2	M and M	1
3	2022-01-02	1	1	5	3	Twizzler	1
4	2022-01-02	2	3	7	4	Skittles	1
1	2022-01-02	2	1	1	1	Chocolate	2
2	2022-01-02	3	2	3	2	Chocolate	2
4	2022-01-02	2	3	6	4	Fudge	3

Order rows are duplicated by the JOIN so computation is overstated.

```
SELECT *
FROM ‘orders.csv’ orders
LEFT JOIN ‘items.csv’ AS items ON orders.order_id = items.order_id
```

order_id	order_date	shipping_cost	user_id	item_id	order_id	item	price
1	2022-01-01	2	1	2	1	Twizzler	1
2	2022-01-01	3	2	4	2	M and M	1
3	2022-01-02	1	1	5	3	Twizzler	1
4	2022-01-02	2	3	7	4	Skittles	1
1	2022-01-02	2	1	1	1	Chocolate	2
2	2022-01-02	3	2	3	2	Chocolate	2
4	2022-01-02	2	3	6	4	Fudge	3

Order rows are duplicated by the JOIN so computation is overstated.

Combine Result Rectangles

(Traditional data warehousing)

```
WITH orders_date AS (
   SELECT
      order_date,
      sum(shipping_cost) AS total_shipping
   FROM ‘orders.csv’
   GROUP BY 1
),
```

order_date	total_shipping
2022-01-01	5
2022-01-02	3

```
WITH items_date AS (
   SELECT
      order_date,
      sum(price) AS total_revenue
   FROM ‘orders.csv’ AS orders
   JOIN ‘items.csv’ AS items
     ON orders.order_id = items.order_id
   GROUP BY 1
)
```

order_date	total_revenue
2022-01-01	6
2022-01-02	5

```
SELECT
   orders_date.order_date,
   total_revenue,
   total_shipping
FROM orders_date
JOIN items_date
  ON orders_date.order_date =
   items_date.order_date
```

order_date	total_revenue	total_shipping
2022-01-01	6	5
2022-01-02	5	3

```
WITH orders_date AS (
  SELECT
    order_date,
    sum(shipping_cost) AS total_shipping
  FROM 'orders.csv'
  GROUP BY 1
),
```

order_date	total_shipping
2022-01-01	5
2022-01-02	3

```
WITH items_date AS (
  SELECT
    order_date,
    sum(price) AS total_revenue
  FROM 'orders.csv' AS orders
  JOIN 'items.csv' AS items
    ON orders.order_id = items.order_id
  GROUP BY 1
)
```

order_date	total_revenue
2022-01-01	6
2022-01-02	5

```
SELECT
  orders_date.order_date,
  total_revenue,
  total_shipping
FROM orders_date
JOIN items_date
  ON orders_date.order_date =
    items_date.order_date
```

order_date	total_revenue	total_shipping
2022-01-01	6	5
2022-01-02	5	3

order_date	total_revenue	total_shipping
2022-01-01	6	5
2022-01-02	5	3

order_date	total_revenue	total_shipping
2022-01-01	6	5
2022-01-02	5	3

user_id	total_revenue	total_shipping
1	4	3
2	3	3
3	4	2

```
WITH orders_date AS (
  SELECT
    order_date,
    sum(shipping_cost) AS total_shipping
  FROM ‘orders.csv’
  GROUP BY 1
),

WITH items_date AS (
  SELECT
    order_date,
    sum(price) AS total_revenue
  FROM ‘orders.csv’ AS orders
  JOIN ‘items.csv’ AS items
    ON orders.order_id = items.order_id
  GROUP BY 1
)

SELECT
  orders_date.order_date,
  total_revenue,
  total_shipping
FROM orders_date
JOIN items_date
  ON orders_date.order_date =
    items_date.order_date
```

```sql
WITH orders_date AS (
  SELECT
    order_date,
    sum(shipping_cost) AS total_shipping
  FROM ‘orders.csv’
  GROUP BY 1
),

WITH items_date AS (
  SELECT
    order_date,
    sum(price) AS total_revenue
  FROM ‘orders.csv’ AS orders
  JOIN ‘items.csv’ AS items
    ON orders.order_id = items.order_id
  GROUP BY 1
)

SELECT
  orders_date.order_date,
  total_revenue,
  total_shipping
FROM orders_date
JOIN items_date
  ON orders_date.order_date =
    items_date.order_date
```

```
WITH orders_user_id AS (
  SELECT
    user_id,
    sum(shipping_cost) AS total_shipping
  FROM ‘orders.csv’
  GROUP BY 1
),

WITH items_user_id AS (
  SELECT
    user_id,
    sum(price) AS total_revenue
  FROM ‘orders.csv’ AS orders
  JOIN ‘items.csv’ AS items
    ON orders.order_id = items.order_id
  GROUP BY 1
)

SELECT
  order_user_id.use_id,
  total_revenue,
  total_shipping
FROM orders_user_id
JOIN orders_user_id
  ON orders_user_id.user_id =
   items_user_id.user_id
```

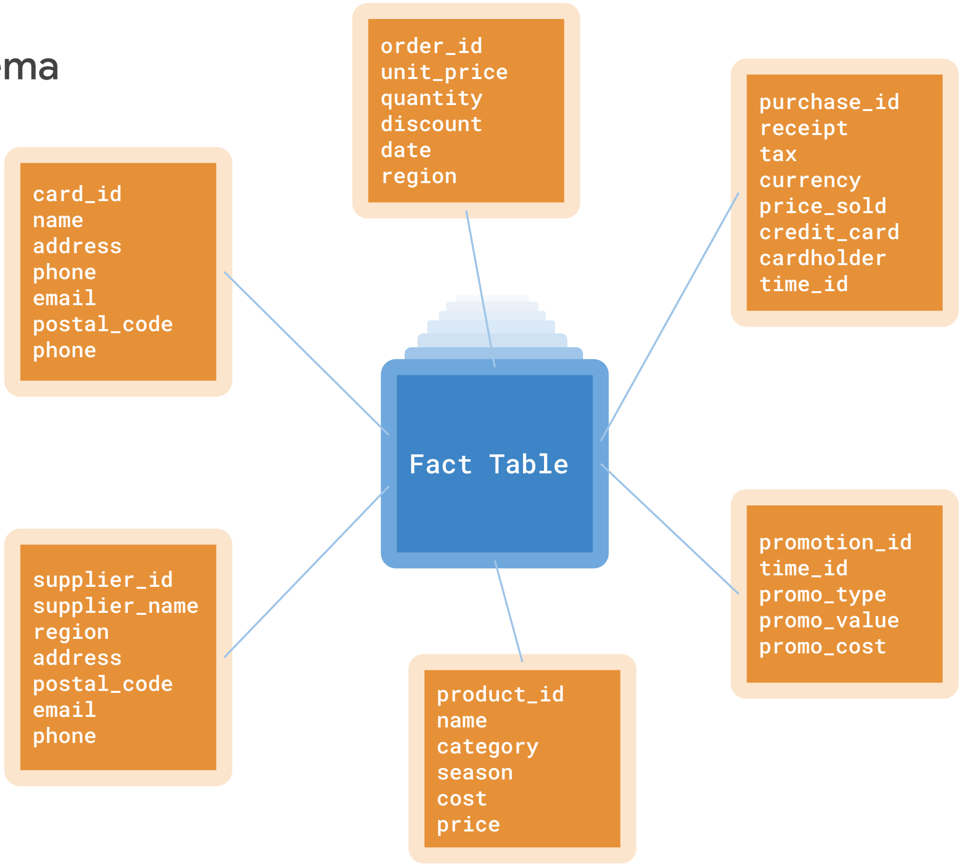
```
WITH orders_user_id AS (
  SELECT
    user_id,
    sum(shipping_cost) AS total_shipping
  FROM ‘orders.csv’
  GROUP BY 1
),

WITH items_user_id AS (
  SELECT
    user_id,
    sum(price) AS total_revenue
  FROM ‘orders.csv’ AS orders
  JOIN ‘items.csv’ AS items
    ON orders.order_id = items.order_id
  GROUP BY 1
)

SELECT
  order_user_id.use_id,
  total_revenue,
  total_shipping
FROM orders_user_id
JOIN orders_user_id
  ON orders_user_id.user_id =
   items_user_id.user_id
```

order_date	total_shipping
2022-01-01	5
2022-01-02	3

order_date	total_revenue
2022-01-01	6
2022-01-02	5

order_date	total_revenue	total_shipping
2022-01-01	6	5
2022-01-02	5	3

Traditional data warehouse star schema



Traditional Data Warehousing (Star Schema)

Designed at a time when

- databases were slow
- data was relatively big

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Not real time - reporting only

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ETL from storage format to reporting format

Enter Malloy

Malloy makes the promise that join relations won’t affect aggregate calculations.

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Data is first described in a network. The network of joined rectangles is a reusable object called a source.

Malloy makes the promise that join relations won’t affect aggregate calculations.

Data is first described in a network. The network of joined rectangles is a reusable object called a source.

In a query operation, aggregate calculations are applied. The aggregate calculations can reference any ‘locality’ in the join network and will compute results correctly.

Malloy

```
query: table(‘duckdb:orders.csv’) + {
  join_many: items is table(‘duckdb:items.csv’)
    on order_id = items.order_id
}
-> {
  group_by: order_date
  aggregate:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
order_by: 1
}`
```

Malloy

```
query: table('duckdb:orders.csv') + {
  join_many: items is table('duckdb:items.csv')
    on order_id = items.order_id
}
-> {
  group_by: order_date
  aggregate:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
  order_by: 1
}
```

SOURCE

Malloy

```
query: table('duckdb:orders.csv') + {
  join_many: items is table('duckdb:items.csv')
    on order_id = items.order_id
}
-> {
  group_by: order_date
  aggregate:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
  order_by: 1
}
```

LOCAL TO ITEMS

Malloy

```
query: table('duckdb:orders.csv') + {
  join_many: items is table('duckdb:items.csv')
    on order_id = items.order_id
}
-> {
  group_by: order_date
  aggregate:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
  order_by: 1
}
```

LOCAL TO ORDERS

Malloy

```
query: table(‘duckdb:orders.csv’) + {
  join_many: items is table(‘duckdb:items.csv’)
    on order_id = items.order_id
}
-> {
  group_by: order_date
  aggregate:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
  order_by: 1
}
```

Malloy

```
query: table('duckdb:orders.csv') + {
  join_many: items is table('duckdb:items.csv')
    on order_id = items.order_id
}
-> {
  group_by: order_date
  aggregate:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
  order_by: 1
}
```

order_date	total_revenue	total_shipping
2022-01-01	6	5
2022-01-02	5	3

Malloy

```
query: table('duckdb:orders.csv') + {
  join_many: items is table('duckdb:items.csv')
    on order_id = items.order_id
}
-> {
  group_by: user_id
  aggregate:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
  order_by: 1
}
```

user_id	total_revenue	total_shipping
1	4	3
2	3	3
3	4	2

```
WITH orders_user_id as (
  SELECT
    user_id,
    sum(shipping_cost) AS total_shipping
  FROM 'orders.csv'
  GROUP BY 1
),

WITH items_user_id as (
  SELECT
    user_id,
    sum(price) AS total_revenue
  FROM 'orders.csv' AS orders
  JOIN 'items.csv' AS items
    ON orders.order_id = items.order_id
  GROUP BY 1
)

SELECT
  order_user_id.use_id,
  total_revenue,
  total_shipping
FROM orders_user_id
JOIN orders_user_id
  ON orders_user_id.user_id =
   items_user_id.user_id
```

```
query: table('duckdb:orders.csv') + {
  join_many: items is
table('duckdb:items.csv')
    on order_id = items.order_id
}
-> {
  group_by: user_id
  aggregate:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
order_by: 1
}`
```

Dimensional Freedom

Produce results from anywhere in the join network

```
SELECT
  base.”order_date” AS “order_date”,
  COALESCE(SUM(items_0.”price”),0) AS “total_revenue”,
  COALESCE((
    SELECT sum(a.val) AS value
    FROM (
      SELECT UNNEST(list(distinct {key:base.”__distinct_key”,
val: base.”shipping_cost”})) a
        )
      ),0) AS “total_shipping”
FROM (SELECT GEN_RANDOM_UUID() AS __distinct_key, * FROM orders.csv
AS x) AS base
LEFT JOIN items.csv AS items_0
  ON base.”order_id”=items_0.”order_id”
GROUP BY 1
ORDER BY 1 ASC NULLS LAST
```

Malloy’s reusability is a source

```
source: orders_items is table(‘duckdb:orders.csv’) + {
  join_many: items is table(‘duckdb:items.csv’)
    on order_id = items.order_id
  declare:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
}
```

Sources are named

```
source: orders_items is table(‘duckdb:orders.csv’) + {
  join_many: items is table(‘duckdb:items.csv’)
    on order_id = items.order_id
  declare:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
}
```

Sources describe the join relationships

```
source: orders_items is table(‘duckdb:orders.csv’) + {
  join_many: items is table(‘duckdb:items.csv’)
    on order_id = items.order_id
  declare:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
}
```

Sources describe the calculations (aggregate and scalar)

```
source: orders_items is table('duckdb:orders.csv') + {
  join_many: items is table('duckdb:items.csv')
    on order_id = items.order_id
  declare:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
}
```

Sources describe the calculations (aggregate and scalar)

```
source: orders_items is table(‘duckdb:orders.csv’) + {
  join_many: items is table(‘duckdb:items.csv’)
    on order_id = items.order_id
  declare:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
}
```

```
source: orders_items is table('duckdb:orders.csv') + {
  join_many: items is table('duckdb:items.csv')
    on order_id = items.order_id
  declare:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
}
```

Using a source makes queries very simple

```
query: orders_items -> {
  group_by: order_date
  aggregate: total_revenue, total_shipping
  order_by: 1
}
```

```
  join_many: items is table('duckdb:items.csv')
    on order_id = items.order_id
  declare:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
}
```

Using a source makes queries very simple

```
query: orders_items -> {
  group_by: order_date
  aggregate: total_revenue, total_shipping
  order_by: 1
}

query: orders_items -> {
  group_by: user_id
  aggregate: total_revenue, total_shipping
  order_by: 1
}
```

```
    total_shipping is shipping_cost.sum()
}
```

Using a source makes queries very simple

```
query: orders_items -> {
  group_by: order_date
  aggregate: total_revenue, total_shipping
  order_by: 1
}

query: orders_items -> {
  group_by: user_id
  aggregate: total_revenue, total_shipping
  order_by: 1
}

query: orders_items -> {
  aggregate: total_revenue
}
```

```
[
  {
    “order_id”: 1,
    “order_date”: “2022-01-01”,
    “shipping_cost”: 2,
    “user_id”: 1,
    “items”: [
      {
        “item_id”: 1,
        “item”: “Chocolate”,
        “price”: 2
      },
      {
        “item_id”: 2,
        “item”: “Twizzler”,
        “price”: 1
      }
    ]
  },
  {
    “order_id”: 2,
    “order_date”: “2022-01-01”.
```

column_name	column_type	null	key
order_id	INTEGER	YES	
order_date	DATE	YES	
shipping_cost	INTEGER	YES	
user_id	INTEGER	YES	
items	STRUCT(item_id INTEGER, item VARCHAR, price INTEGER)[]	YES	

```
query: table('duckdb:orders_items.parquet')
-> {
  group_by: order_date
  aggregate:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
  order_by: 1
}
```

order_date	total_revenue	total_shipping
2022-01-01	6	5
2022-01-02	5	3

```
query:
table(‘duckdb:orders_items.parquet’)
-> {
  group_by: order_date
  aggregate:
    total_revenue is items.price.sum()
    total_shipping is shipping_cost.sum()
  nest: by_items is {
    group_by: items.item
    aggregate: total_revenue is
     items.price.sum()
  }
  order_by: 1
}
```

order_date	total_revenue	total_shipping	by_items	
2022-01-01	6	5	item	total_revenue
			Chocolate	4
			Twizzler	1
			M and M	1
2022-01-02	5	3	item	total_revenue
			Fudge	3
			Skittles	1
			Twizzler	1

```
 WITH __stage0 AS (
  SELECT
    group_set,
    CASE WHEN group_set IN (0,1) THEN
      base."order_date"
      END as "order_date__0",
    CASE WHEN group_set=0 THEN
      COALESCE(SUM(base.items[items_0.__row_id]."price"),0)
      END as "total_revenue__0",
    CASE WHEN group_set=0 THEN
      COALESCE((
          SELECT sum(a.val) as value
          FROM (
            SELECT UNNEST(list(distinct {key:base."__distinct_key",
val: base."shipping_cost"})) a
          )
        ),0)
      END as "total_shipping__0",
    CASE WHEN group_set=1 THEN
      base.items[items_0.__row_id]."item"
      END as "item__1",
    CASE WHEN group_set=1 THEN
      COALESCE(SUM(base.items[items_0.__row_id]."price"),0)
      END as "total_revenue__1"
  FROM (SELECT GEN_RANDOM_UUID() as __distinct_key, * FROM
orders_items.parquet as x) as base
  LEFT JOIN (select UNNEST(generate_series(1,
          100000, --
          -- (SELECT genres_length FROM movies limit 1),
          1)) as __row_id) as items_0 ON  items_0.__row_id <=
array_length(base."items")
  CROSS JOIN (SELECT UNNEST(GENERATE_SERIES(0,1,1)) as group_set  )
as group_set
  GROUP BY 1,2,5
)
SELECT
  "order_date__0" as "order_date",
  MAX(CASE WHEN group_set=0 THEN total_revenue__0 END) as
"total_revenue",
  MAX(CASE WHEN group_set=0 THEN total_shipping__0 END) as
"total_shipping",
  COALESCE(LIST({
    "item": "item__1",
    "total_revenue": "total_revenue__1"}  ORDER BY
"total_revenue__1" desc NULLS LAST) FILTER (WHERE group_set=1),[]) as
"by_items"
FROM __stage0
GROUP BY 1
ORDER BY 1 ASC NULLS LAST
```

Demo

http://www.malloydata.dev