What you write is not what SQL sees

IMPROVING QUERY PERFORMANCE IN POSTGRESQL

Amy McCarty
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Algebraic order of operations

- Lexical (as written)
- Logical (as executed)

PEMDAS	BODMAS
Parenthesis	Brackets
Exponents	Order
Multiplication /Division	Division /Multiplication
Addition /Subtraction	Addition /Subtraction

Applying the order of operations

Lexical:

$$x = 2 + (8 + 4) \div 2$$

$$x = 10 + 4) \div 2$$

$$x = 14 \div 2$$

$$x = 7$$

Logical:

$$x = 2 + (8 + 4) \div 2$$

$$x = 2 + \frac{12}{2}$$

$$x = 2 + 6$$

$$x = 8$$

SQL logical order of operations

Order	Clause	Purpose
1	**FROM**	Provides directions to the table or tables if the query includes joins
2	**WHERE**	Filters or limits the records
3	**GROUP BY**	Places records into categories
4	**SUM(), COUNT()**, etc	Aggregates
5	**SELECT**	identifies columns to return

```
SELECT COUNT(*) FROM tableA WHERE col1 = 77
```

Group by and aggregations

event_location	storm	elements	days
Russia	blizzard	water	1
Argentina	tornado	water	1
Argentina	tornado	wind	1
Australia	tornado	wind	1
Kuwait	haboob	wind	2
USA	haboob	wind	2

```sql
SELECT elements, storm, COUNT(*)
FROM weather_events
GROUP BY elements
```

```
No output -
your code generated an error

column "storm" must appear in the
GROUP BY clause or be used in an
aggregate function
```

Group by and aggregations order of operations

```
SELECT elements, storm, COUNT(*)
FROM weather_events
GROUP BY elements
```

order	SQL clause	available columns
1	FROM weather_events	all
3	GROUP BY elements	elements
4	COUNT	elements

Group by matches the aggregations

```
SELECT elements, storm, COUNT(*)
FROM weather_events
GROUP BY elements, storm
```

Group by matches the aggregations

```
SELECT elements, storm, COUNT(*)
FROM weather_events
GROUP BY elements, storm
```

Results

elements	storm	count
water	blizzard	1
water	tornado	1
wind	tornado	2
wind	haboob	2

SQL logical order of operations continued

Order	Clause	Purpose
...		
5	**SELECT**	identifies columns to return
6	**DISTINCT**	removes duplicates
7	**ORDER BY**	arranges results
8	**LIMIT**	removes rows

Distinct and limit

row_no	location	storm	elements	days
1	Russia	blizzard	water	1
2	Argentina	tornado	water	1
3	Argentina	tornado	wind	1
4	Australia	tornado	wind	1
5	Kuwait	haboob	wind	2
6	USA	haboob	wind	2

```
SELECT DISTINCT storm, elements
FROM weather_events
ORDER BY storm LIMIT 3
```

row_no	location	storm	elements	days
1	Russia	blizzard	water	1
2	Argentina	tornado	water	1
3	Argentina	tornado	wind	1
4	Australia	tornado	wind	1
5	Kuwait	haboob	wind	2
6	USA	haboob	wind	2

```
SELECT DISTINCT storm, elements
FROM weather_events
ORDER BY storm LIMIT 3
```

row_no	location	storm	elements	days
1	Russia	blizzard	water	1
2	Argentina	tornado	water	1
3	Argentina	tornado	wind	1
4	Australia	tornado	wind	1
5	Kuwait	haboob	wind	2
6	USA	haboob	wind	2

order	SQL clause	available rows
1	FROM weather_events	all

```
SELECT DISTINCT storm, elements
FROM weather_events
ORDER BY storm LIMIT 3
```

row_no	storm	elements
1	blizzard	water
2	tornado	water
3	tornado	wind
5	haboob	wind

order	SQL clause	available rows
1	FROM weather_events	all
5	SELECT storm, elements	all

```sql
SELECT DISTINCT storm, elements
FROM weather_events
ORDER BY storm LIMIT 3
```

row_no	storm	elements
1	blizzard	water
2	tornado	water
3	tornado	wind
5	haboob	wind

order	SQL clause	available rows
1	FROM weather_events	all
5	SELECT storm, elements	all
6	DISTINCT	1, 2, 3, 5

```
SELECT DISTINCT storm, elements
FROM weather_events
ORDER BY storm LIMIT 3
```

row_no	storm	elements
1	blizzard	water
5	haboob	wind
2	tornado	water
3	tornado	wind

order	SQL clause	available rows
1	FROM weather_events	all
5	SELECT storm, elements	all
6	DISTINCT	1, 2, 3, 5
7	ORDER BY storm	1, 5, 2, 3

```
SELECT DISTINCT storm, elements
FROM weather_events
ORDER BY storm LIMIT 3
```

row_no	storm	elements
1	blizzard	water
5	haboob	wind
2	tornado	water

order	SQL clause	available rows
1	FROM weather_events	all
5	SELECT storm, elements	all
6	DISTINCT	1, 2, 3, 5
7	ORDER BY storm	1, 5, 2, 3
8	LIMIT 3	1, 5, 2

```
SELECT DISTINCT storm, elements
FROM weather_events
ORDER BY storm LIMIT 3
```

Order	Clause	Purpose	Limits
1	**FROM**	provides directions to the table(s)	
2	**WHERE**	filters or limits the records	# rows
3	**GROUP BY**	places records into categories	# columns
4	**SUM**, **COUNT**, etc	aggregates	# rows
5	**SELECT**	identifies columns to return	# columns
6	**DISTINCT**	removes duplicates	# rows
7	**ORDER BY**	arranges results	
8	**LIMIT**	filters records	# rows

Let's practice!

IMPROVING QUERY PERFORMANCE IN POSTGRESQL

Filtering in the WHERE clause

IMPROVING QUERY PERFORMANCE IN POSTGRESQL

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Limit the data

Order	Clause	Purpose
1	FROM	provides directions to the table(s)
2	**WHERE**	**filters or limits the records**

- Occurs early
- Fewer records

EXPLAIN

```
EXPLAIN
SELECT * FROM phones
```

```
Seq Scan on phones (cost = 0.00..22.7
                    ,rows=1270
                    ,width=36)
```

- Number of execution steps

Query planner

EXPLAIN with WHERE

```
EXPLAIN
SELECT * FROM phones
WHERE phone_code = 235
```

```
Seq Scan on phones (cost = 0.00..25.8
                    ,rows=6,width=636)
  Filter: (phone_code=235)
```

Query planner

Good - Filtering for similar values with LIKE OR

country	phone_code	reliability
Chad	235	medium
China	86	high
Costa Rica	506	high
India	91	medium
Indonesia	62	medium
Iraq	964	low

```sql
EXPLAIN
SELECT * FROM phones
WHERE country LIKE 'Ch%'
  OR country LIKE 'In%'
```

```
Seq Scan on phones (cost = 0.00..29.05
                   ,rows=13,width=36)
  Filter: ((country~~'Ch%'::text)
           OR(country~~'In%'::text))
```

Better - Filtering for similar values with LIKE ANY

country	phone_code	reliability
Chad	235	medium
China	86	high
Costa Rica	506	high
India	91	medium
Indonesia	62	medium
Iraq	964	low

```
EXPLAIN
SELECT * FROM phones
WHERE country
  LIKE ANY(ARRAY['Ch%','In%'])
```

```
Seq Scan on phones (cost = 0.00..25.88
                         ,rows=13,width=36)
  Filter: ((country~~ANY('{Ch%,In%}'
                              ::text[]))
```

Good - Filtering for exact values with OR

country	phone_code	reliability
Chad	235	medium
China	86	high
Costa Rica	506	high
India	91	medium
Indonesia	62	medium
Iraq	964	low

```
EXPLAIN
SELECT * FROM phones
WHERE country = 'Chad'
  OR country = 'China'
```

```
Seq Scan on phones (cost = 0.00..29.05
                   ,rows=13,width=36)
  Filter: ((country='Chad'::text)
           OR(country='China'::text))
```

Better - Filtering for exact values with IN

country	phone_code	reliability
Chad	235	medium
China	86	high
Costa Rica	506	high
India	91	medium
Indonesia	62	medium
Iraq	964	low

```sql
EXPLAIN
SELECT * FROM phones
WHERE country IN ('Chad','China')
```

```
Seq Scan on phones (cost = 0.00..25.88
                       ,rows=13,width=36)
  Filter: ((country=ANY('{Chad,China}'
                         ::text[]))
```

Best - Filtering for numbers

country	phone_code	reliability
Chad	235	medium
China	86	high
Costa Rica	506	high
India	91	medium
Indonesia	62	medium
Iraq	964	low

```sql
EXPLAIN
SELECT *
FROM phones
WHERE phone_code IN (235,86)
```

```
Seq Scan on phones (cost = 0.00..25.88
                     ,rows=13,width=36)
  Filter: (phone_code=ANY('{235,86}'
                          ::integer[]))
```

Summarizing the best WHERE filters

Numeric advantages

- Shorter length
- Smaller storage
- Speeds performance

Summarizing the best WHERE filters

Numeric advantages

- Shorter length
- Smaller storage
- Speeds performance

Good	Better
Text	Numeric
OR	IN, ARRAY

Let's practice!

IMPROVING QUERY PERFORMANCE IN POSTGRESQL

Filtering while joining

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Joins revisited

Joins

- Link tables using at least 1 common field

```
SELECT *
FROM TABLE_A AS A
INNER JOIN TABLE_B AS B
  ON A.NAME = B.NAME
```

Joins to combine data

- From multiple tables
- Inner and outer

Joins to filter data

- Inner join
- Outer join with non-linking join condition

Patient and appointments data

Appointments

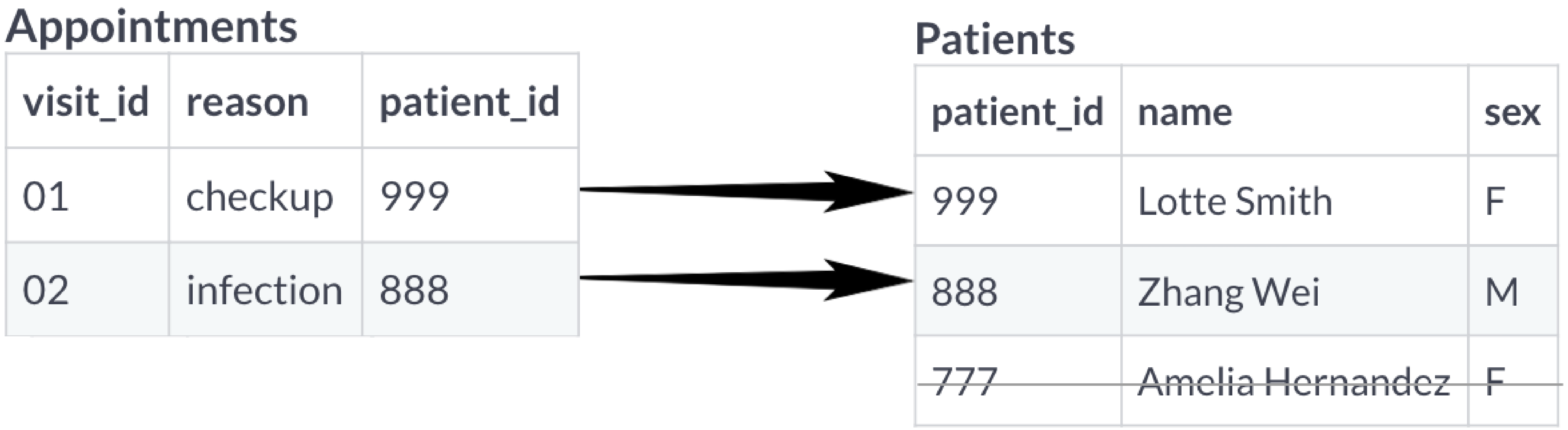
visit_id	reason	patient_id
01	checkup	999
02	infection	888

Patients

patient_id	name	sex
999	Lotte Smith	F
888	Zhang Wei	M
777	Amelia Hernandez	F

Inner joins to filter

```
SELECT *
FROM appointments a
INNER JOIN patients p
ON a.patient_id = p.patient_id
```



Appointments

visit_id	reason	patient_id
01	checkup	999
02	infection	888

Patients

patient_id	name	sex
999	Lotte Smith	F
888	Zhang Wei	M
~~777~~	~~Amelia Hernandez~~	~~F~~

Inner joins to filter

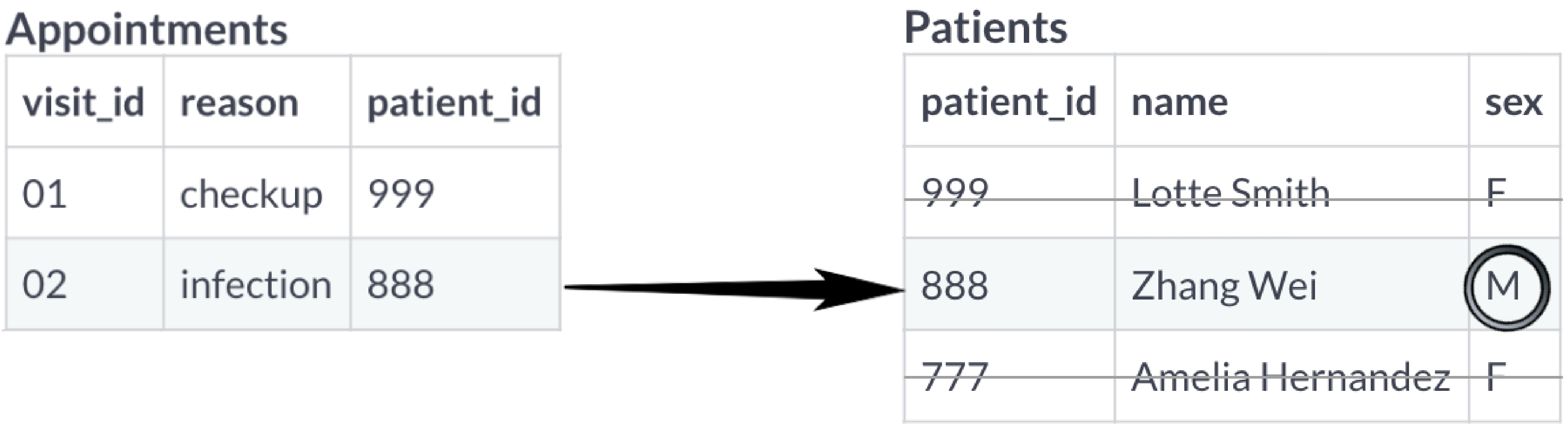
```
SELECT *
FROM appointments a
INNER JOIN patients p
ON a.patient_id = p.patient_id
```

Output

visit_id	reason	patient_id	name	sex
01	checkup	999	Lotte Smith	F
02	infection	888	Zhang Wei	M

Outer joins to filter

```
SELECT *
FROM appointments a
LEFT JOIN patients p
  ON a.patient_id = p.patient_id
  AND p.sex = 'M'
```



Appointments

visit_id	reason	patient_id
01	checkup	999
02	infection	888

Patients

patient_id	name	sex
~~999~~	~~Lotte Smith~~	~~F~~
888	Zhang Wei	M
~~777~~	~~Amelia Hernandez~~	~~F~~

Outer joins to filter

```
SELECT *
FROM appointments a
LEFT JOIN patients p
  ON a.patient_id = p.patient_id
  AND p.sex = 'M'
```

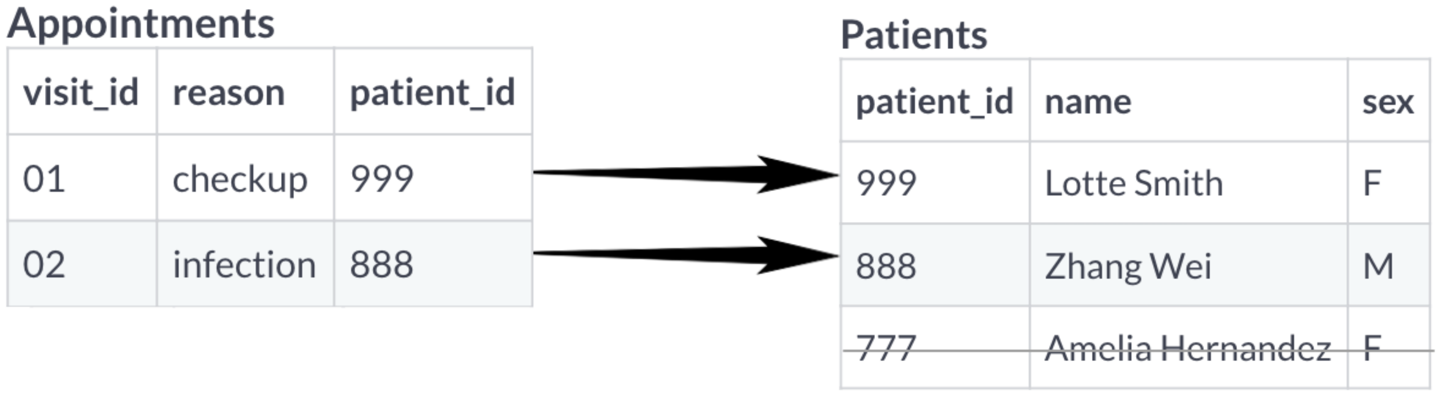
Output

visit_id	reason	patient_id	name	sex
01	checkup	999		
02	infection	888	Zhang Wei	M

Filter pitfalls

```
SELECT *
FROM appointments a
LEFT JOIN patients p
  ON a.patient_id = p.patient_id
WHERE p.sex = 'M'
```

1) FROM



Appointments

visit_id	reason	patient_id
01	checkup	999
02	infection	888

Patients

patient_id	name	sex
999	Lotte Smith	F
888	Zhang Wei	M
~~777~~	~~Amelia Hernandez~~	~~F~~

2) WHERE

Output

visit_id	reason	patient_id	name	sex
~~01~~	~~checkup~~	~~999~~	~~Lotte Smith~~	~~F~~
02	infection	888	Zhang Wei	M

Filter pitfalls

```
SELECT *
FROM appointments a
LEFT JOIN patients p
  ON a.patient_id = p.patient_id
WHERE p.sex = 'M'
```

Output

visit_id	reason	patient_id	name	sex
02	infection	888	Zhang Wei	M

Filter pitfalls

```
SELECT *
FROM appointments a
LEFT JOIN patients p
  ON a.patient_id = p.patient_id
WHERE p.sex = 'M'
```

```
SELECT *
FROM appointments a
LEFT JOIN patients p
  ON a.patient_id = p.patient_id
  AND p.sex = 'M'
```

Output

visit_id	reason	patient_id	name	sex
02	infection	888	Zhang Wei	M

visit_id	reason	patient_id	name	sex
01	checkup	999		
02	infection	888	Zhang Wei	M

Filter pitfalls improved

```
SELECT *
FROM appointments a
INNER JOIN patients p
  ON a.patient_id = p.patient_id
WHERE p.sex = 'M'
```

visit_id	reason	patient_id	name	sex
02	infection	888	Zhang Wei	M

```
SELECT *
FROM appointments a
INNER JOIN patients p
  ON a.patient_id = p.patient_id
  AND p.sex = 'M'
```

Let's practice!

IMPROVING QUERY PERFORMANCE IN POSTGRESQL

Aggregating with different data granularities

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Data granularity - level of detail

- Makes a row unique
- 1+ columns

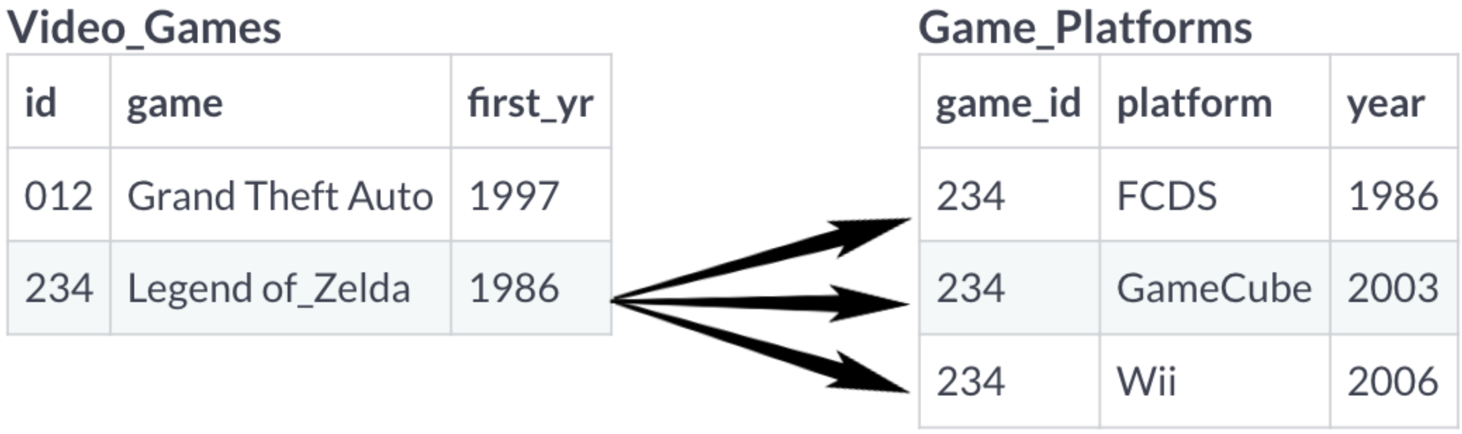
Video_Games

id	game	first_yr
012	Grand Theft Auto	1997
234	Legend of_Zelda	1986

Game_Platforms

game_id	platform	year
234	FCDS	1986
234	GameCube	2003
234	Wii	2006

Joining different granularities



Video_Games

id	game	first_yr
012	Grand Theft Auto	1997
234	Legend of_Zelda	1986

Game_Platforms

game_id	platform	year
234	FCDS	1986
234	GameCube	2003
234	Wii	2006

id	game	first_yr	no_platforms
234	Legend_of_Zelda	1986	3
234	Legend_of_Zelda	1986	3
234	Legend_of_Zelda	1986	3

```
SELECT g.id, g.game, g.first_yr
  , COUNT(platform) AS no_platforms
FROM video_games g
INNER JOIN game_platforms p
  ON g.id = p.game_id
GROUP BY g.id, g.game, g.first_yr
```

Changing the table granularity

Game_Platforms

game_id	platform	year
234	FCDS	1986
234	GameCube	2003
234	Wii	2006

```
SELECT game_id
  , COUNT(platform) as no_platforms
FROM game_platforms
GROUP BY game_id
```

Changing the table granularity

Game_Platforms

game_id	platform	year
234	FCDS	1986
234	GameCube	2003
234	Wii	2006

```
SELECT game_id
  , COUNT(platform) as no_platforms
FROM game_platforms
GROUP BY game_id
```

Output

game_id	no_platforms
234	3

CTEs revisited

- Standalone query with temporary results set
- With statement structure

```
WITH cte AS
   ( SELECT * FROM tableA )

SELECT * FROM cte
```

    - Allows aggregation before joining

CTEs to the granularity rescue

```
WITH platforms_cte AS
(   SELECT game_id
     , COUNT(platforms) as no_platforms
   FROM game_platforms
   GROUP BY game_id
)
```

```
SELECT g.id, g.game , cte.no_platforms
FROM video_games g
INNER JOIN platforms_cte cte
  ON g.id = cte.game_id
```

CTEs to the granularity rescue

```
WITH platforms_cte AS
(   SELECT game_id
       , COUNT(platforms) as no_platforms
    FROM game_platforms
    GROUP BY game_id
)
```

```
SELECT g.id, g.game , cte.no_platforms
FROM video_games g
INNER JOIN platforms_cte cte
  ON g.id = cte.game_id
```

Output

id	game	no_platforms
234	Legend of Zelda	3

Matching data granularity when joining

- No repeats or duplicates
- Minimum needed results
- No double counting

Let's practice!

IMPROVING QUERY PERFORMANCE IN POSTGRESQL