

```
SELECT  
  'amazing_features'  
FROM  
  "postgresql"
```













# Postgres 95





# PostgreSQL v1





PostgreSQL v6...





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Google Developer Expert  
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Gitlab Heroes



Open Source Contributor





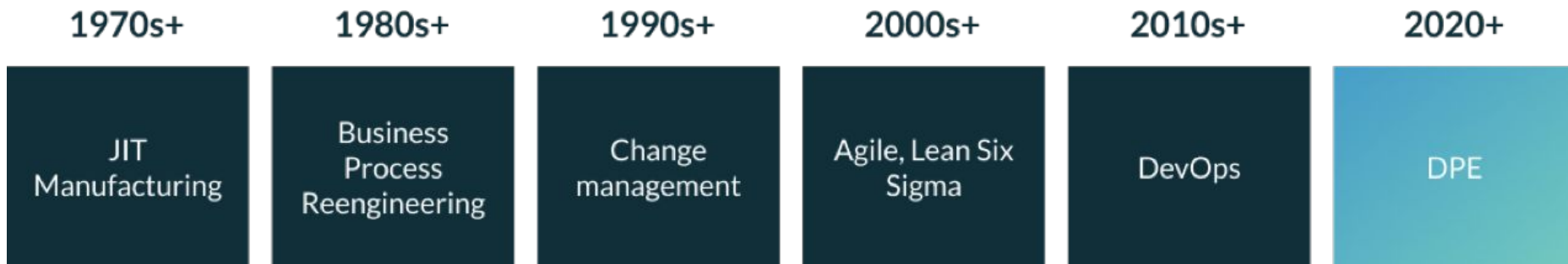




Our mission at **Gradle** is to **accelerate developer productivity** and  
**make developers happier**



What comes after DevOps?



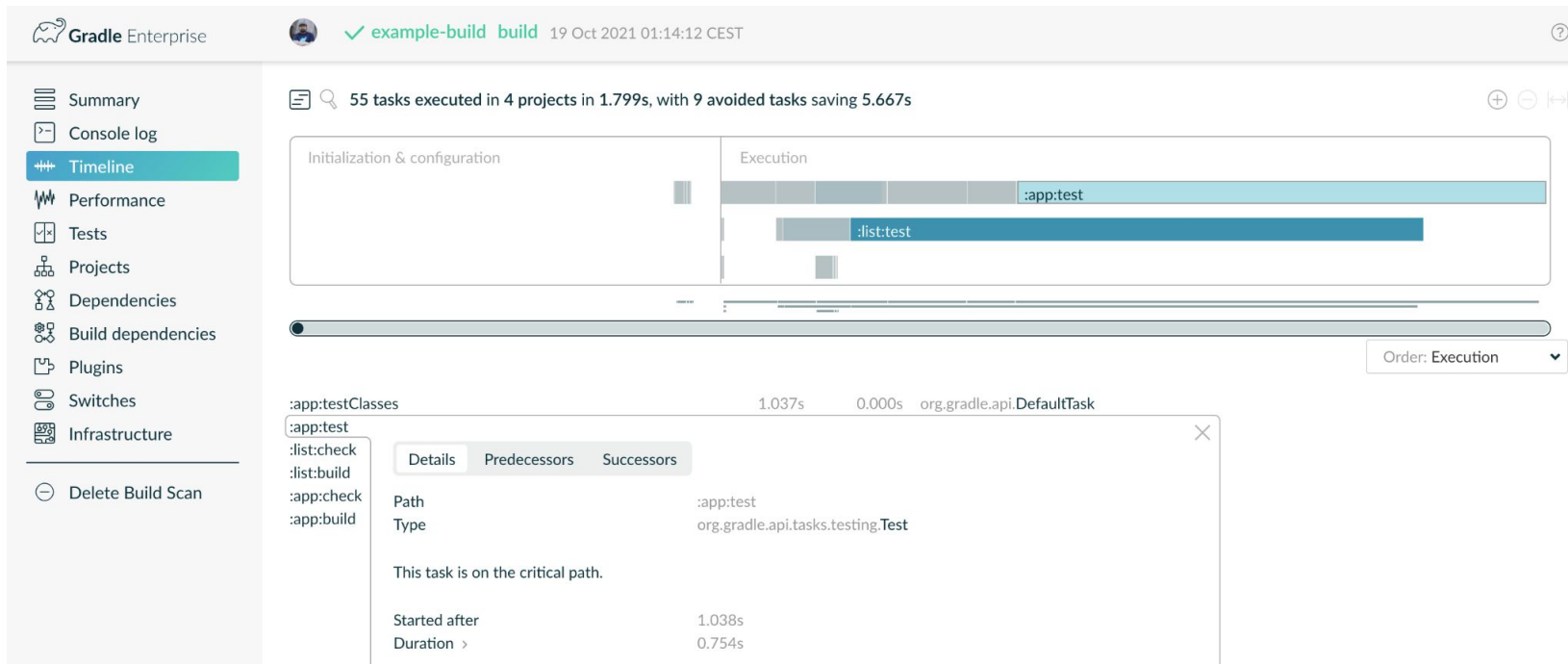
**Developer Productivity Engineering**





# “If you can’t measure it, you can’t improve it!”

by Peter Drucker



# Structured Query Language





# Standard ISO/IEC 9075-1



SQL:1986





SQL:2016







SQL:2023



**Never  
Forget  
The order...**



From  
Join

Where

Group by

Aggregate  
Functions

Having

Window  
Functions

Select

Distinct

Union  
Intersect  
Except

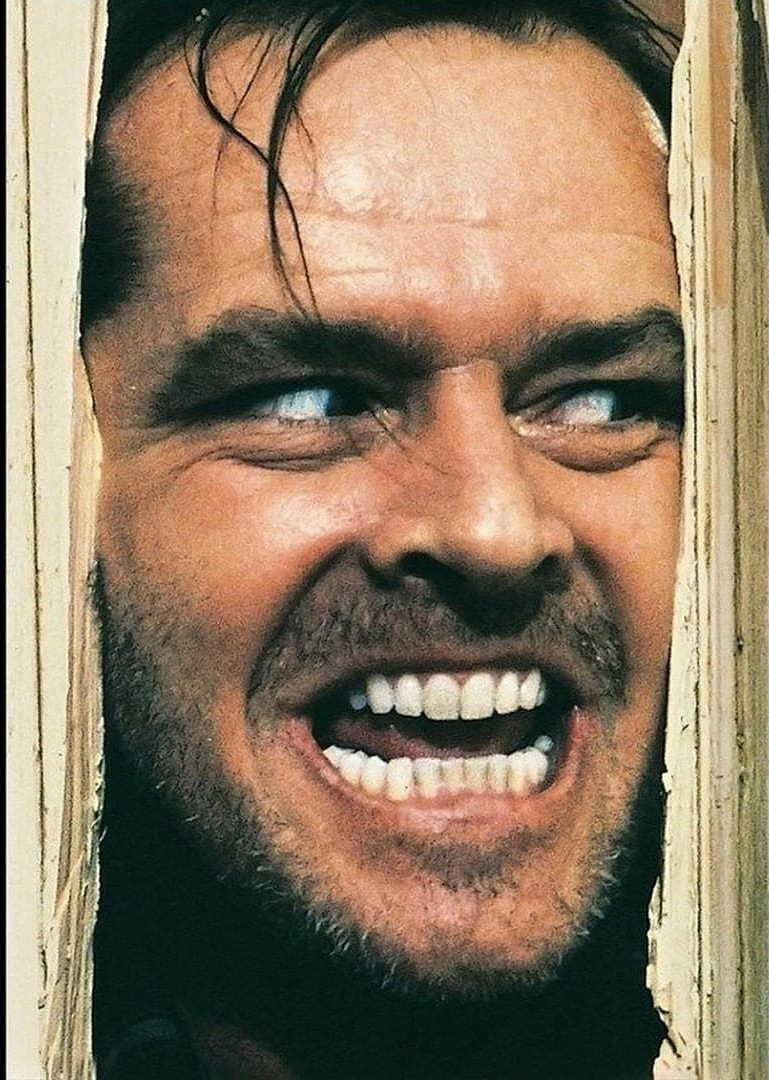
Order by

Offset

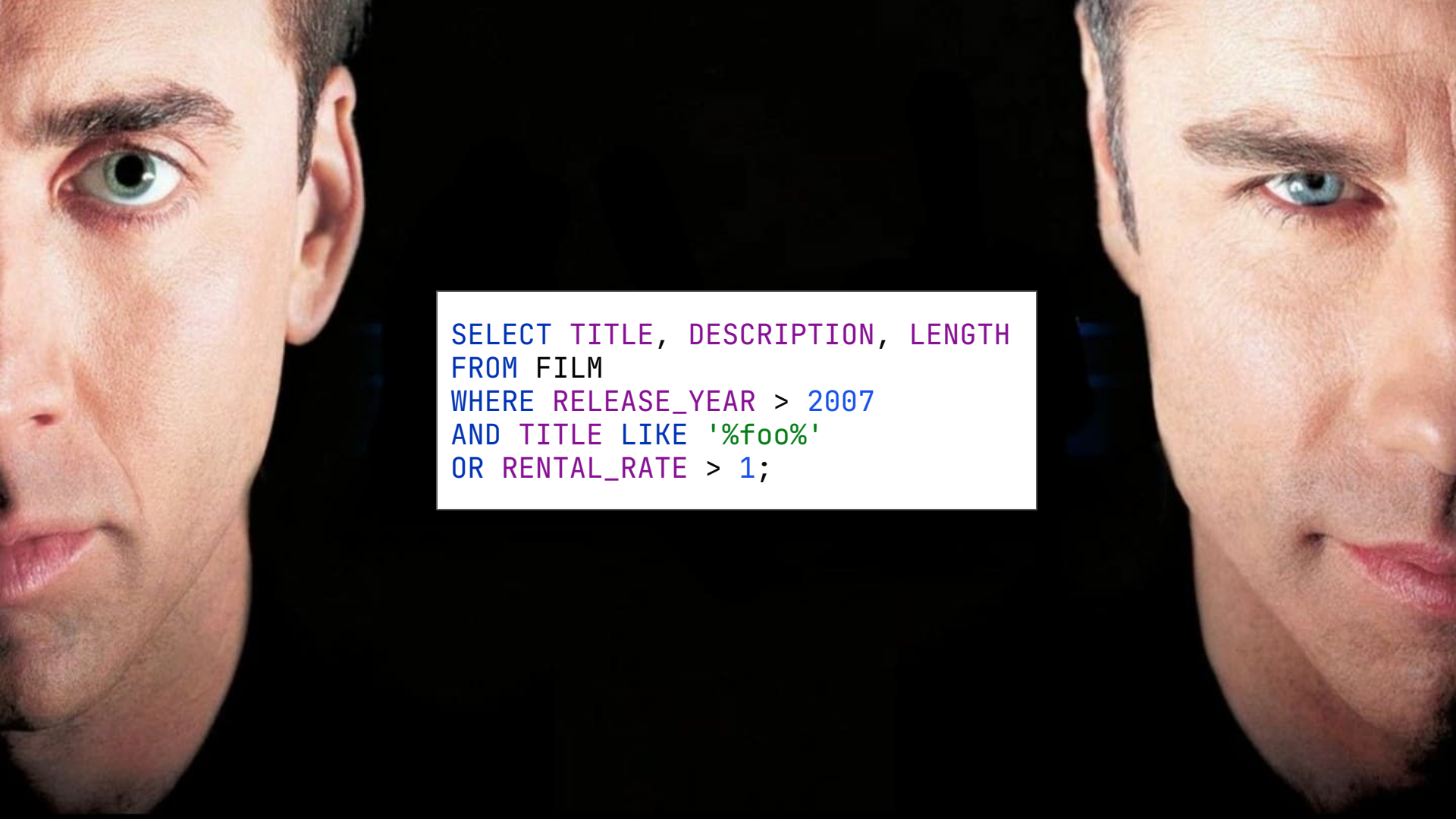
Limit  
Fetch  
Top



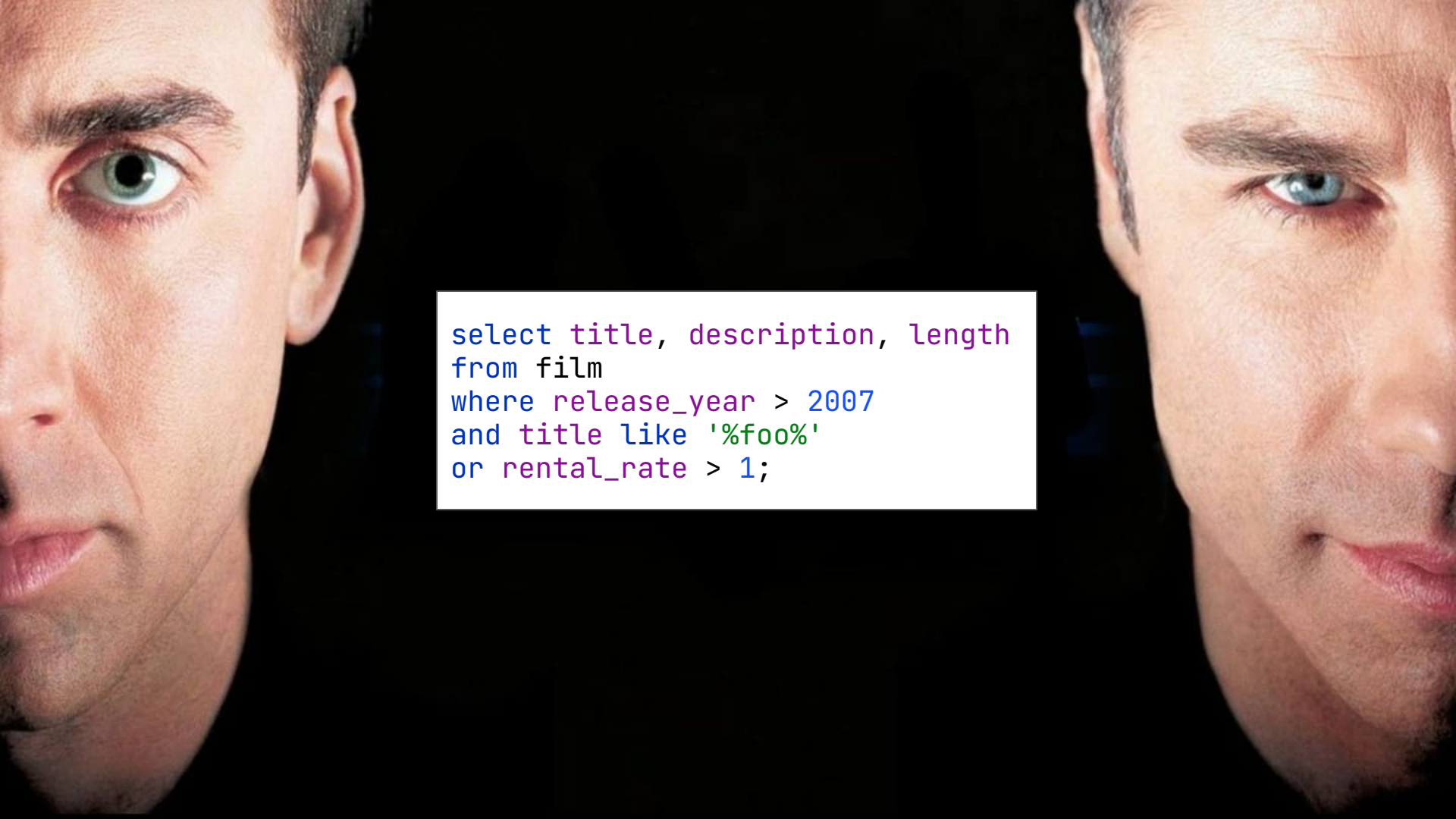
Don't need to  
shout...







```
SELECT TITLE, DESCRIPTION, LENGTH  
FROM FILM  
WHERE RELEASE_YEAR > 2007  
AND TITLE LIKE '%foo%'  
OR RENTAL_RATE > 1;
```



```
select title, description, length
from film
where release_year > 2007
and title like '%foo%'
or rental_rate > 1;
```

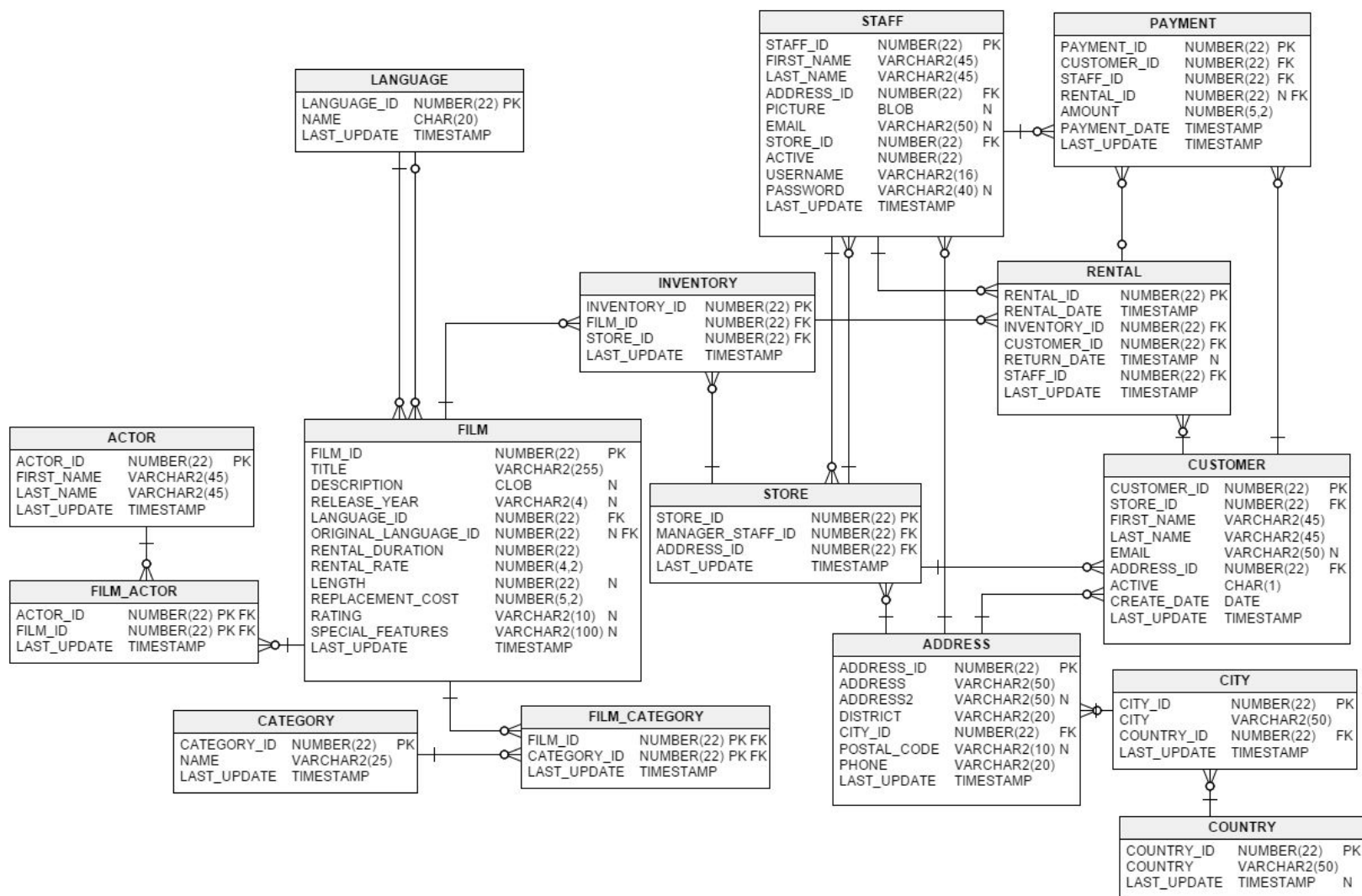


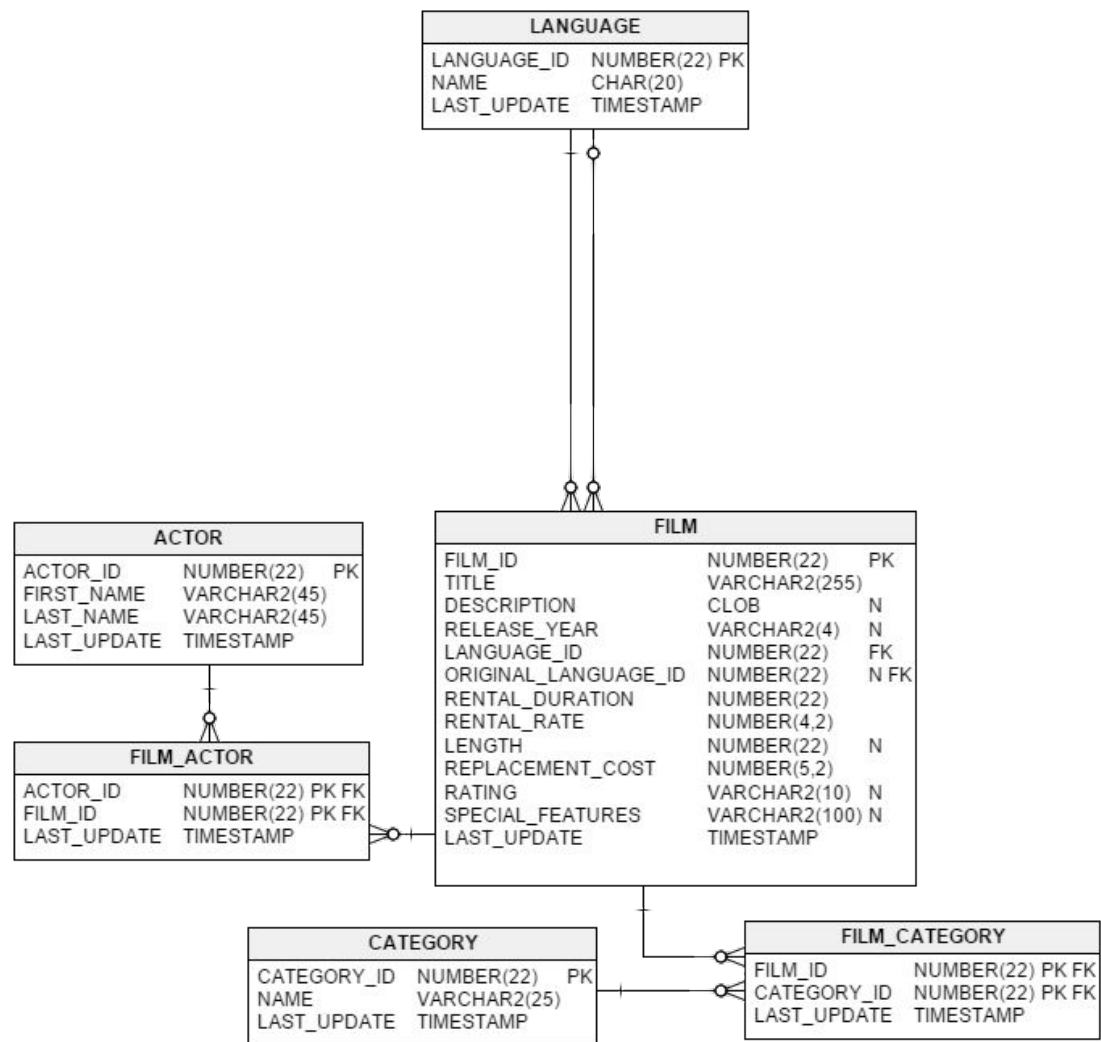




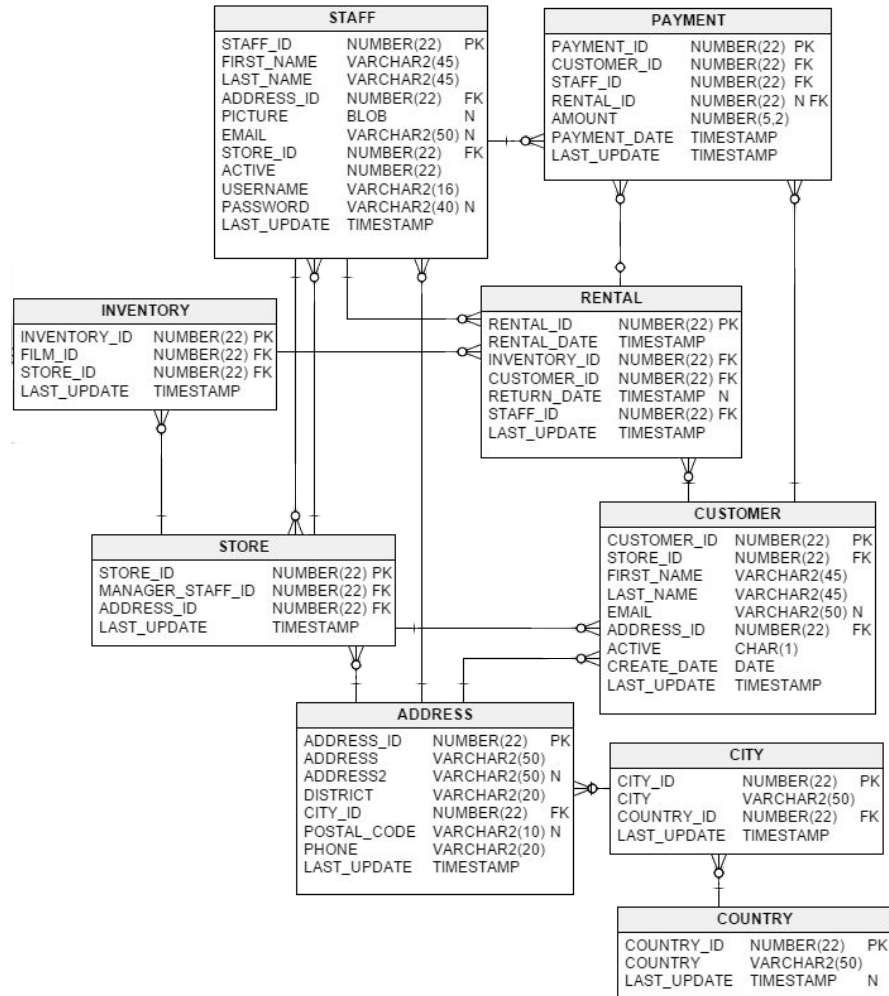
# Sakila Database



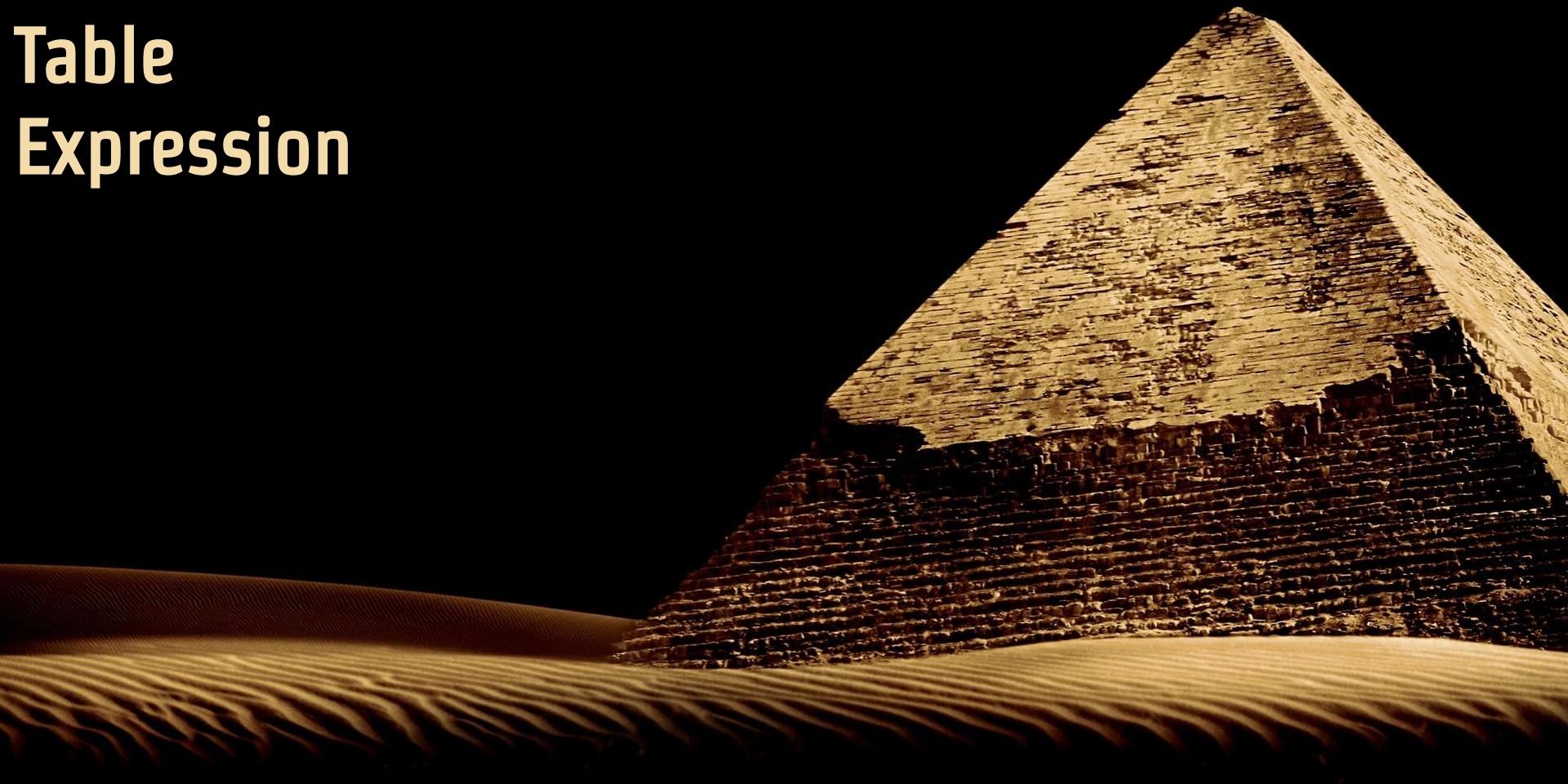


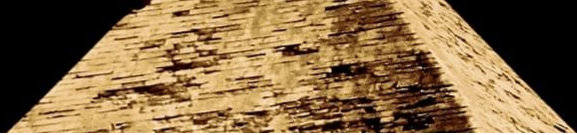






# Common Table Expression



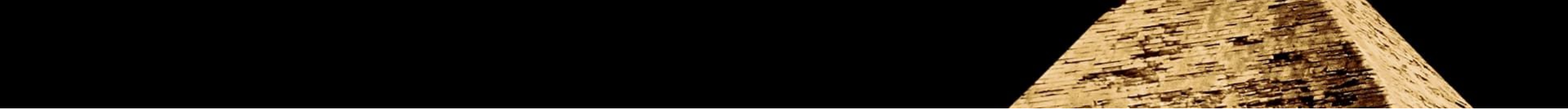


```
select
  c.first_name || ' ' || c.last_name,
  sum(amount)
from
  customer c
  join (
    select r.customer_id
    from rental r
      inner join inventory i on r.inventory_id = i.inventory_id
      inner join film f on i.film_id = f.film_id
      inner join film_category fc on f.film_id = fc.film_id
      inner join category cat on cat.category_id = fc.category_id
    where cat.name = 'Documentary'
    group by r.customer_id
  ) r on c.customer_id = r.customer_id
  join payment ps on c.customer_id = ps.customer_id
group by c.first_name, c.last_name
order by 2 desc;
```





```
var result = foo(bar(baz(1, foo(2,3)), really(4, tooMuch(5,6))), 7);
```



```
var first = tooMuch(5, 6);  
var second = foo(2, 3);  
var third = really(4, first);  
var fourth = baz(1, second);  
var last = bar(fourth, third);  
var result = foo(last, 7);
```



Better readability



# Better readability

```
with documentary_rentals as (  
    select r.customer_id  
    from rental r  
        inner join inventory i on r.inventory_id = i.inventory_id  
        inner join film f on i.film_id = f.film_id  
        inner join film_category fc on f.film_id = fc.film_id  
        inner join category cat on cat.category_id = fc.category_id  
    where cat.name = 'Documentary'  
    group by r.customer_id  
)  
select  
    c.first_name || ' ' || c.last_name,  
    sum(ps.amount)  
from  
    customer c  
        join documentary_rentals r on c.customer_id = r.customer_id  
        join payment ps on c.customer_id = ps.customer_id  
group by c.first_name, c.last_name  
order by 2 desc
```

Naming  
is important



# Naming is important



```
with documentary_rentals as (  
    select r.customer_id  
    from rental r  
        inner join inventory i on r.inventory_id = i.inventory_id  
        inner join film f on i.film_id = f.film_id  
        inner join film_category fc on f.film_id = fc.film_id  
        inner join category cat on cat.category_id = fc.category_id  
    where cat.name = 'Documentary'  
    group by r.customer_id  
)  
select  
    c.first_name || ' ' || c.last_name,  
    sum(ps.amount)  
from  
    customer c  
        join documentary_rentals r on c.customer_id = r.customer_id  
        join payment ps on c.customer_id = ps.customer_id  
group by c.first_name, c.last_name  
order by 2 desc
```



# Faster Execution



# Faster Execution

```
with
  first_cte as (...),
  second_cte as (...),
  third_cte as (...)
select
  c.first_name || ' ' || c.last_name,
  sum(ps.amount)
from
  ...
group by c.first_name, c.last_name
order by 2 desc
```



# Window Functions





From  
Join

Where

Group by

Aggregate  
Functions

Having

Window  
Functions

Select

Distinct

Union  
Intersect  
Except

Order by

Offset

Limit  
Fetch  
Top



# Window Functions

```
select rating, count(*) as "number of movie"  
from film  
group by rating;
```

rating	number of movie
PG	194
G	178
NC-17	210
PG-13	223
R	195

filter()





```
select
  count(*) as "all",
  count(*) filter ( where rating = 'PG' ) as "PG",
  count(*) filter ( where rating = 'G' ) as "G",
  count(*) filter ( where rating = 'NC-17' ) as "NC-17",
  count(*) filter ( where rating = 'PG-13' ) as "PG-13",
  count(*) filter ( where rating = 'R' ) as "R"
from film;
```

all	PG	G	NC-17	PG-13	R
1000	194	178	210	223	195

select

```
count(*) filter ( where length > 30 ) as "> 30m",  
count(*) filter ( where length > 60 ) as "> 60m",  
count(*) filter ( where length > 90 ) as "> 90m",  
count(*) filter ( where length > 120 ) as "> 120m",  
count(*) filter ( where length > 180 ) as "> 180m"  
from film;
```

> 30m	> 60m	> 90m	> 120m	> 180m
1000	896	675	457	39

```

select
  count(*) as "all",
  count(*) filter ( where rating = 'PG' ) as "PG",
  count(*) filter ( where rating = 'G' ) as "G",
  count(*) filter ( where rating = 'NC-17' ) as "NC-17",
  count(*) filter ( where rating = 'PG-13' ) as "PG-13",
  count(*) filter ( where rating = 'R' ) as "R",
  count(*) filter ( where length > 30 ) as "> 30m",
  count(*) filter ( where length > 60 ) as "> 60m",
  count(*) filter ( where length > 90 ) as "> 90m",
  count(*) filter ( where length > 120 ) as "> 120m",
  count(*) filter ( where length > 180 ) as "> 180m"
from film

```

all	PG	G	NC-17	PG-13	R	> 30m	> 60m	> 90m	> 120m	> 180m
1000	194	178	210	223	195	1000	896	675	457	39



LAG() & LEAD()



```
select count(*) as "# of time rented", title
from film
  inner join inventory i using (film_id)
  inner join rental r using (inventory_id)
  inner join customer c using (customer_id)
group by film_id, title
order by "# of time rented" desc, film_id;
```

# of time rented	title
34	BUCKET BROTHERHOOD
33	ROCKETEER MOTHER
32	FORWARD TEMPLE
32	GRIT CLOCKWORK
32	JUGGLER HARDLY
...	...

# LAG() & LEAD()

```
select
  c.first_name || ' ' || c.last_name as "rented by", date_trunc('day', r.rental_date),
  lag(c.first_name || ' ' || c.last_name)
    over (partition by i.inventory_id order by rental_date) as "rented previously by",
  lead(c.first_name || ' ' || c.last_name)
    over (partition by i.inventory_id order by rental_date) as "rented later by"
from film
  inner join inventory i using (film_id)
  inner join rental r using (inventory_id)
  inner join customer c using (customer_id)

where title = 'BUCKET BROTHERHOOD';
```

rented by	date_trunc	rented previously by	rented later by
LORETTA CARPENTER	2005-07-11	<null>	WILLIE MARKHAM
WILLIE MARKHAM	2005-07-28	LORETTA CARPENTER	BOBBY BOUDREAU
BOBBY BOUDREAU	2005-08-21	WILLIE MARKHAM	<null>
MONICA HICKS	2005-05-25	<null>	ANTONIO MEEK
ANTONIO MEEK	2005-06-17	MONICA HICKS	SETH HANNON
SETH HANNON	2005-07-12	ANTONIO MEEK	TARA RYAN
TARA RYAN	2005-07-29	SETH HANNON	JUAN FRALEY
JUAN FRALEY	2005-08-17	TARA RYAN	<null>



# LAG() & LEAD()

```
select
  c.first_name || ' ' || c.last_name as "rented by", date_trunc('day', r.rental_date),
  lag(c.first_name || ' ' || c.last_name) over rd as "rented previously by",
  lead(c.first_name || ' ' || c.last_name) over rd as "rented later by"
from film
  inner join inventory i using (film_id)
  inner join rental r using (inventory_id)
  inner join customer c using (customer_id)
where title = 'BUCKET BROTHERHOOD'
window rd as (partition by i.inventory_id order by rental_date);
```

rented by	date_trunc	rented previously by	rented later by
LORETTA CARPENTER	2005-07-11	<null>	WILLIE MARKHAM
WILLIE MARKHAM	2005-07-28	LORETTA CARPENTER	BOBBY BOUDREAU
BOBBY BOUDREAU	2005-08-21	WILLIE MARKHAM	<null>
MONICA HICKS	2005-05-25	<null>	ANTONIO MEEK
ANTONIO MEEK	2005-06-17	MONICA HICKS	SETH HANNON
SETH HANNON	2005-07-12	ANTONIO MEEK	TARA RYAN
TARA RYAN	2005-07-29	SETH HANNON	JUAN FRALEY
JUAN FRALEY	2005-08-17	TARA RYAN	<null>

[dense\_]rank()





# [dense\_]rank()

```
select f.title, count(*) as "# of time rented"
from film f
  inner join inventory i on f.film_id = i.film_id
  inner join rental r on i.inventory_id = r.inventory_id
group by f.film_id, f.title
order by 2 desc
```

title	# of time rented
BUCKET BROTHERHOOD	34
ROCKETEER MOTHER	33
FORWARD TEMPLE	32
GRIT CLOCKWORK	32
JUGGLER HARDLY	32
RIDGEMONT SUBMARINE	32
SCALAWAG DUCK	32
APACHE DIVINE	31
GOODFELLAS SALUTE	31
...	...



# [dense\_]rank()

```
with film_order_by_rent_success(title, times_rented) as (  
  select f.title, count(*) as "# of time rented"  
  from film f  
    inner join inventory i on f.film_id = i.film_id  
    inner join rental r on i.inventory_id = r.inventory_id  
 group by f.film_id, f.title  
)  
select  
  title, times_rented,  
  rank() over (order by times_rented desc),  
  dense_rank() over (order by times_rented desc)  
from film_order_by_rent_success;
```

title	times_rented	rank	dense_rank
BUCKET BROTHERHOOD	34	1	1
ROCKETEER MOTHER	33	2	2
FORWARD TEMPLE	32	3	3
GRIT CLOCKWORK	32	3	3
JUGGLER HARDLY	32	3	3
RIDGEMONT SUBMARINE	32	3	3
SCALAWAG DUCK	32	3	3
APACHE DIVINE	31	8	4
GOODFELLAS SALUTE	31	8	4
...			

# [dense\_]rank()

```
with
  film_order_by_rent_success(title, times_rented) as (...),
  film_ranked (title, times_rented, rank, dense_rank) as (
    select
      title, times_rented,
      rank() over (order by times_rented desc),
      dense_rank() over (order by times_rented desc)
    from film_order_by_rent_success
  )
select title, times_rented, rank, dense_rank
from film_ranked
limit 4
```

title	times_rented	rank	dense_rank
BUCKET BROTHERHOOD	34	1	1
ROCKETEER MOTHER	33	2	2
FORWARD TEMPLE	32	3	3
GRIT CLOCKWORK	32	3	3
JUGGLER HARDLY	32	3	3
RIDGEMONT SUBMARINE	32	3	3
SCALAWAG DUCK	32	3	3
APACHE DIVINE	31	8	4
GOODFELLAS SALUTE	31	8	4
...			

# [dense\_]rank()

```
with
  film_order_by_rent_success(title, times_rented) as (...),
  film_ranked (title, times_rented, rank, dense_rank) as (
    select
      title, times_rented,
      rank() over (order by times_rented desc),
      dense_rank() over (order by times_rented desc)
    from film_order_by_rent_success
  )
select title, times_rented, rank, dense_rank
from film_ranked
where rank ≤ 4
```

title	times_rented	rank	dense_rank
BUCKET BROTHERHOOD	34	1	1
ROCKETEER MOTHER	33	2	2
FORWARD TEMPLE	32	3	3
GRIT CLOCKWORK	32	3	3
JUGGLER HARDLY	32	3	3
RIDGEMONT SUBMARINE	32	3	3
SCALAWAG DUCK	32	3	3
APACHE DIVINE	31	8	4
GOODFELLAS SALUTE	31	8	4
...			



# [dense\_]rank()

```
with
  film_order_by_rent_success(title, times_rented) as (...),
  film_ranked (title, times_rented, rank, dense_rank) as (
    select
      title, times_rented,
      rank() over (order by times_rented desc),
      dense_rank() over (order by times_rented desc)
    from film_order_by_rent_success
  )
select title, times_rented, rank, dense_rank
from film_ranked
where dense_rank ≤ 4
```

title	times_rented	rank	dense_rank
BUCKET BROTHERHOOD	34	1	1
ROCKETEER MOTHER	33	2	2
FORWARD TEMPLE	32	3	3
GRIT CLOCKWORK	32	3	3
JUGGLER HARDLY	32	3	3
RIDGEMONT SUBMARINE	32	3	3
SCALAWAG DUCK	32	3	3
APACHE DIVINE	31	8	4
GOODFELLAS SALUTE	31	8	4
...			

A black and white photograph of a man's face, heavily obscured by a dense, chaotic overlay of mathematical formulas, numbers, and symbols. The formulas include expressions like  $1+1=2$ ,  $2+2=4$ ,  $3+3=6$ ,  $4+4=8$ ,  $5+5=10$ ,  $6+6=12$ ,  $7+7=14$ ,  $8+8=16$ ,  $9+9=18$ ,  $10+10=20$ ,  $11+11=22$ ,  $12+12=24$ ,  $13+13=26$ ,  $14+14=28$ ,  $15+15=30$ ,  $16+16=32$ ,  $17+17=34$ ,  $18+18=36$ ,  $19+19=38$ ,  $20+20=40$ ,  $21+21=42$ ,  $22+22=44$ ,  $23+23=46$ ,  $24+24=48$ ,  $25+25=50$ ,  $26+26=52$ ,  $27+27=54$ ,  $28+28=56$ ,  $29+29=58$ ,  $30+30=60$ ,  $31+31=62$ ,  $32+32=64$ ,  $33+33=66$ ,  $34+34=68$ ,  $35+35=70$ ,  $36+36=72$ ,  $37+37=74$ ,  $38+38=76$ ,  $39+39=78$ ,  $40+40=80$ ,  $41+41=82$ ,  $42+42=84$ ,  $43+43=86$ ,  $44+44=88$ ,  $45+45=90$ ,  $46+46=92$ ,  $47+47=94$ ,  $48+48=96$ ,  $49+49=98$ ,  $50+50=100$ . Other visible formulas include  $1+2=3$ ,  $2+3=5$ ,  $3+4=7$ ,  $4+5=9$ ,  $5+6=11$ ,  $6+7=13$ ,  $7+8=15$ ,  $8+9=17$ ,  $9+10=19$ ,  $10+11=21$ ,  $11+12=23$ ,  $12+13=25$ ,  $13+14=27$ ,  $14+15=29$ ,  $15+16=31$ ,  $16+17=33$ ,  $17+18=35$ ,  $18+19=37$ ,  $19+20=39$ ,  $20+21=41$ ,  $21+22=43$ ,  $22+23=45$ ,  $23+24=47$ ,  $24+25=49$ ,  $25+26=51$ ,  $26+27=53$ ,  $27+28=55$ ,  $28+29=57$ ,  $29+30=59$ ,  $30+31=61$ ,  $31+32=63$ ,  $32+33=65$ ,  $33+34=67$ ,  $34+35=69$ ,  $35+36=71$ ,  $36+37=73$ ,  $37+38=75$ ,  $38+39=77$ ,  $39+40=79$ ,  $40+41=81$ ,  $41+42=83$ ,  $42+43=85$ ,  $43+44=87$ ,  $44+45=89$ ,  $45+46=91$ ,  $46+47=93$ ,  $47+48=95$ ,  $48+49=97$ ,  $49+50=99$ . The man's eyes are visible through the formulas, looking directly at the camera. The background is dark and textured. In the top left corner, the text 'row\_number()' is written in a white, monospace font.



row\_number()

```
create table film_with_duplicate (  
    film_id serial primary key,  
    title character varying(255) not null  
);
```

```
insert into film_with_duplicate (title)  
    -- all original films are inserted  
    (select title from film)  
union all  
    -- and we insert 40 random films from the same list  
    (select title from film order by random() limit 40);
```





# row\_number()



```
select count(*) as "number of films"  
from film_with_duplicate;
```

number of films
1040



row\_number()

```
select title, film_id
from film_with_duplicate
order by title;
```

title	film_id
-----+-----	
ACADEMY DINOSAUR	1074
ACE GOLDFINGER	1747
<b>ADAPTATION HOLES</b>	<b>1986</b>
<b>ADAPTATION HOLES</b>	<b>2034</b>
AFFAIR PREJUDICE	1614
AFRICAN EGG	1047





# row\_number()

```
select title, film_id
       row_number() over (partition by title) as duplication_times,
from film_with_duplicate
```

title	duplication_times	film_id
ACADEMY DINOSAUR	1	1074
ACE GOLDFINGER	1	1747
ADAPTATION HOLES	1	1986
<b>ADAPTATION HOLES</b>	<b>2</b>	<b>2034</b>
AFFAIR PREJUDICE	1	1614
AFRICAN EGG	1	1047



# row\_number()

```
with iteration_of_each_film_entry as (  
    select title, film_id,  
           row_number() over (partition by title) as duplication_times  
    from film_with_duplicate  
)  
delete from film_with_duplicate  
where film_id IN (  
    select distinct film_id  
    from iteration_of_each_film_entry  
    where duplication_times > 1  
);
```

title	duplication_times	film_id
ACADEMY DINOSAUR	1	1074
ACE GOLDFINGER	1	1747
ADAPTATION HOLES	1	1986
<b>ADAPTATION HOLES</b>	<b>2</b>	<b>2034</b>
AFFAIR PREJUDICE	1	1614
AFRICAN EGG	1	1047





Join Lateral



# Join Lateral

```
select f.title, rental_date,  
       row_number() over (partition by f.title order by rental_date desc)  
from film f  
join inventory i on f.film_id = i.film_id  
join rental r on i.inventory_id = r.inventory_id  
order by title, rental_date desc
```

title	rental_date	row_number
ACADEMY DINOSAUR	2005-08-23 01:01:01	1
ACADEMY DINOSAUR	2005-08-22 23:56:37	2
ACADEMY DINOSAUR	2005-08-22 00:44:08	3
ACADEMY DINOSAUR	2005-08-21 21:27:43	4
ACADEMY DINOSAUR	2005-08-21 18:32:42	5
ACADEMY DINOSAUR	2005-08-21 00:30:32	6
ACADEMY DINOSAUR	2005-08-18 18:36:16	7
ACADEMY DINOSAUR	2005-08-02 20:13:10	8
...		

# Join Lateral

```
with all_rentals (film, rental_date, iteration) as (  
    select f.title, rental_date,  
           row_number() over (partition by f.title order by rental_date desc)  
    from film f  
    join inventory i on f.film_id = i.film_id  
    join rental r on i.inventory_id = r.inventory_id  
    order by title, rental_date desc  
)  
select film, rental_date  
from all_rentals  
where iteration ≤ 3;
```

film	rental_date
ACADEMY DINOSAUR	2005-08-23 01:01:01
ACADEMY DINOSAUR	2005-08-22 23:56:37
ACADEMY DINOSAUR	2005-08-22 00:44:08
ACE GOLDFINGER	2006-02-14 15:16:03
ACE GOLDFINGER	2005-08-22 16:59:05
ACE GOLDFINGER	2005-08-17 09:33:02
ADAPTATION HOLES	2005-08-23 13:54:39
ADAPTATION HOLES	2005-08-22 03:52:21
...	

Do you know  
**for-each**  
?



```
select film.title, recently_rented.rental_date  
from film
```

title

-----  
ACADEMY DINOSAUR  
ACE GOLDFINGER  
ADAPTATION HOLES  
AFFAIR PREJUDICE  
AFRICAN EGG  
AGENT TRUMAN  
AIRPLANE SIERRA  
AIRPORT POLLOCK

...

# Join Lateral


```
select film.title, recently_rented.rental_date
from film
left join lateral (
    select *
    from inventory i
    join rental r on i.inventory_id = r.inventory_id
    where i.film_id = film.film_id -- film from outer query
    order by rental_date desc
    limit 3
) as recently_rented on film.film_id = recently_rented.film_id
order by film.title;
```

title	rental_date
ACADEMY DINOSAUR	2005-08-23 01:01:01
ACADEMY DINOSAUR	2005-08-22 23:56:37
ACADEMY DINOSAUR	2005-08-22 00:44:08
ACE GOLDFINGER	2006-02-14 15:16:03
ACE GOLDFINGER	2005-08-22 16:59:05
ACE GOLDFINGER	2005-08-17 09:33:02
ADAPTATION HOLES	2005-08-23 13:54:39
ADAPTATION HOLES	2005-08-22 03:52:21
...	



Serial is evil





# Serial

```
create table film_serial (  
    id serial primary key,  
    title character varying(255) not null  
);
```

```
insert into film_serial (title)  
values  
    ('Matrix'),  
    ('Matrix Reloaded'),  
    ('Matrix Revolutions'),  
    ('Matrix Resurrections')  
returning id, title;
```



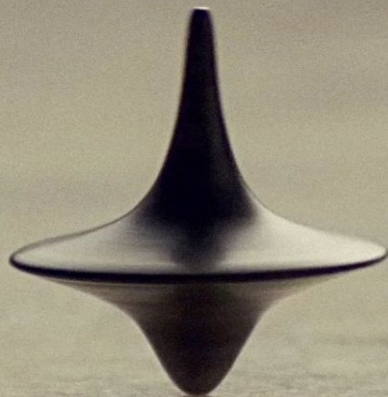


# Serial

id		title
1		Matrix
2		Matrix Reloaded
3		Matrix Revolutions
4		Matrix Resurrections

```
select currval('film_serial_id_seq'::regclass);
```

UUID is better!





# UUID is better!

```
create extension "uuid-oss";
create table if not exists film_uuid (
    id uuid primary key default uuid_generate_v4(),
    title character varying(255) not null
);
```

```
insert into film_uuid (title)
values ('Matrix'),
       ('Matrix Reloaded'),
       ('Matrix Revolutions'),
       ('Matrix Resurrections')
returning id, title;
```



# UUID is better!

id		title
60b8a533-2680-4eaa-a75e-128aa0c67df9		Matrix
45d3f3c9-cbbe-450f-8d14-cbdfd30c1109		Matrix Reloaded
d1687d3e-3d75-4620-8ade-f26c6e8fd8ae		Matrix Revolutions
16f8daf5-2bd5-4816-ac6d-79042ab3b584		Matrix Resurrections





# UUID is better!

```
insert into film_uuid (id, title)
values
  ('4339890d-706f-4950-a862-542f288dca2e'::uuid, 'Matrix'),
  ('b4774c08-8be9-44a4-90aa-8b9af26a5c13'::uuid, 'Matrix Reloaded'),
  ('3f09a064-2f32-41b9-be24-94cc0b068a40'::uuid, 'Matrix Revolutions'),
  ('fae647ab-7c60-4e7c-b4a5-2188b3845f83'::uuid, 'Matrix Resurrections')
-- returning id, title;
```







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s

# Constraints



```
create table film_with_isan (  
  film_id serial primary key,  
  title character varying(255) not null,  
  isan character varying(255)  
  
);
```





# Constraints

```
create table film_with_isan (  
  film_id serial primary key,  
  title character varying(255) not null,  
  isan character varying(255),  
  
  constraint has_valid_isan check (  
    isan is null or  
    isan ~* 'ISAN [0-9a-f]{4}-[0-9a-f]{4}-[0-9a-f]{4}-[0-9a-f]{4}-[0-9a-z]-[0-9a-f]{4}-[0-9a-f]{4}-[0-9a-z]'  
    --      ISAN      0000 -      0001 -      8947 -      0000 -      8-      0000 -      0000 -      D  
  )  
);
```



# Constraints

```
create table film_with_isan (
  film_id serial primary key,
  title character varying(255) not null,
  isan character varying(255),

  constraint has_valid_isan check (
    isan is null or
    isan ~* 'ISAN [0-9a-f]{4}-[0-9a-f]{4}-[0-9a-f]{4}-[0-9a-f]{4}-[0-9a-z]-[0-9a-f]{4}-[0-9a-f]{4}-[0-9a-z]'
    --      ISAN      0000 -      0001 -      8947 -      0000 -      8-      0000 -      0000 -      D
  ),
  constraint isan_is_unique unique (isan)
);
```

# Constraints



```
sakila.public> insert into film_with_isan (title, isan)
                values ('INVALID_ISAN', '63998367-c0c9-4fe0-82fc-ba4c96890ee1');
```

```
[2023-03-25 17:04:37] [23514] ERROR: new row for relation "film_with_isan" violates check constraint "has_valid_isan"
[2023-03-25 17:04:37] Detail: Failing row contains (2042, INVALID_ISAN, 63998367-c0c9-4fe0-82fc-ba4c96890ee1).
```

# Constraints



```
sakila.public> insert into film_with_isan (title, isan)
                values ('REAL_ISAN', 'ISAN 0000-0001-68EC-0000-X-0000-0000-C');
```

```
[2023-03-25 17:07:47] 1 row affected in 13 ms
```

```
sakila.public> insert into film_with_isan (title, isan)
                values ('REAL_ISAN', 'ISAN 0000-0001-68EC-0000-X-0000-0000-C');
```

```
[2023-03-25 17:08:21] [23505] ERROR: duplicate key value violates unique constraint "isan_is_unique"
```

```
[2023-03-25 17:08:21] Detail: Key (isan)=(ISAN 0000-0001-68EC-0000-X-0000-0000-C) already exists.
```



# Type



# Type

```
create type isan_type as (  
    block_1 varchar(4), block_2 varchar(4), block_3 varchar(4), block_4 varchar(4),  
    block_5 varchar(1), block_6 varchar(4), block_7 varchar(4), block_8 varchar(1)  
);
```

```
create domain isan as isan_type check (  
    (value).block_1 is not null and (value).block_1 ~* '[0-9a-f]{4}'  
    and (value).block_2 is not null and (value).block_2 ~* '[0-9a-f]{4}'  
    and (value).block_3 is not null and (value).block_3 ~* '[0-9a-f]{4}'  
    and (value).block_4 is not null and (value).block_4 ~* '[0-9a-f]{4}'  
    and (value).block_5 is not null and (value).block_5 ~* '[0-9a-f]'  
    and (value).block_6 is not null and (value).block_6 ~* '[0-9a-f]{4}'  
    and (value).block_7 is not null and (value).block_7 ~* '[0-9a-f]{4}'  
    and (value).block_8 is not null and (value).block_8 ~* '[0-9a-f]'  
);
```

# Type

```
select ('0000', '0001', '68ec', '0000', 'a', '0000', '0000', 'c')::isan;
```

isan
(0000,0001,68ec,0000,a,0000,0000,c)

# Type

```
select (null, '0001', '68ec', '0000', 'a', '0000', '0000', 'c')::isan;
```

```
[2023-03-29 21:15:46] [23514] ERROR: value for domain isan violates check  
constraint "isan_check"
```




# Type

```
create function isan_to_text(isan) ... $$  
create function text_to_isan(isan) ... $$  
create function isan_exception(text) ... $$  
create function isan_equals(isan) ... $$  
create function isan_not_equals(isan) ... $$
```

```
select  
  isan_equals(  
    text_to_isan('ISAN 0000-0001-68EC-0000-A-0000-0000-C'),  
    text_to_isan('ISAN 0000-0001-68EC-0000-A-0000-0000-C')  
  ) as isan_equality,  
  
  isan_not_equals(  
    ('0000', '0001', '68ec', '0000', 'a', '0000', '0000', 'c')::isan,  
    text_to_isan('ISAN 0000-0001-68EC-0000-A-0000-0000-C')  
  ) as isan_different  
;
```

Type





# Type

```
create operator = (  
  leftarg = isan,  
  rightarg = isan,  
  procedure = isan_equals,  
  commutator = =,  
  negator =  $\neq$ ,  
  hashes,  
  merges  
);
```

```
create operator  $\neq$  (  
  leftarg = isan,  
  rightarg = isan,  
  function = isan_not_equals,  
  commutator =  $\neq$ ,  
  negator = =,  
  hashes,  
  merges  
);
```

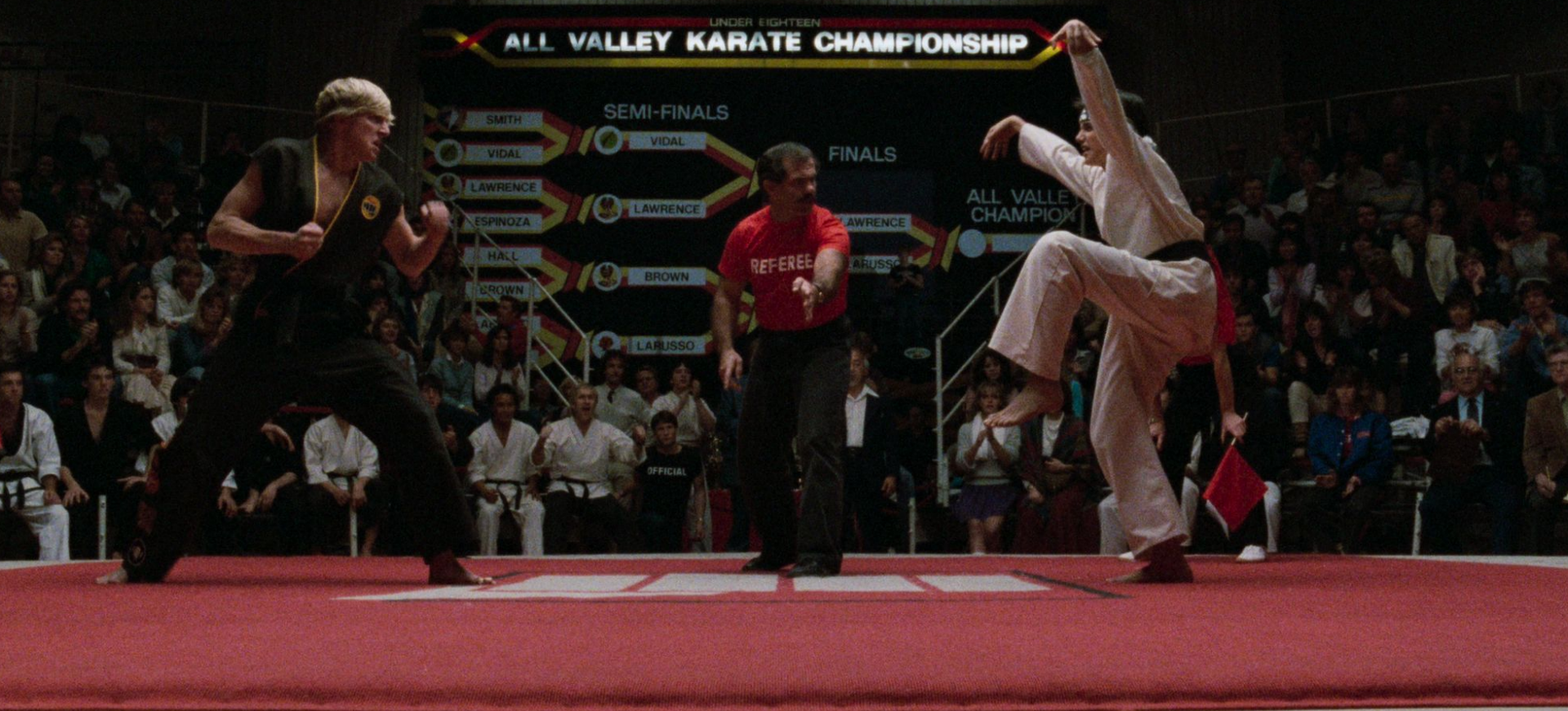
```
select  
  text_to_isan('ISAN 0000-0001-68EC-0000-A-0000-0000-C') = text_to_isan('ISAN 0000-0001-68EC-0000-A-0000-0000-C'),  
  text_to_isan('ISAN 0000-0001-68EC-0000-A-0000-0000-C')  $\neq$  text_to_isan('ISAN 0000-0001-68EC-0000-A-0000-0000-C');
```







on conflict...





# on conflict

```
create table film (  
  film_id serial primary key,  
  title character varying(255) not null,  
  
  last_update timestamp with time zone default now() not null,  
  constraint unique_title unique (title)  
);
```



```
select title, last_update
from film
```

title	last_update
ACADEMY DINOSAUR	2000-01-01 20:00:01.000000+00
ACE GOLDFINGER	2000-01-01 20:00:01.000000+00

```
insert into film (title, last_update)
values ('ACADEMY DINOSAUR', '2023-01-02 03:04:05.678910+00'::timestampz),
       ('ACE GOLDFINGER', '2023-01-02 03:04:05.678910+00'::timestampz),
       ('JUST FOR DEMO', '2023-01-02 03:04:05.678910+00'::timestampz)
on conflict on constraint unique_title do update
set last_update = now();
```

title	last_update
ACADEMY DINOSAUR	2023-06-28 20:20:20.000000+00
ACE GOLDFINGER	2023-06-28 20:20:20.000000+00
JUST FOR DEMO	2023-01-02 03:04:05.000000+00



Merge





# Merge

```
create table film (  
    film_id serial primary key,  
    title character varying(255) not null,  
  
    rating mpaa_rating default 'G'::mpaa_rating,  
    number_of_time_requested integer default 0  
);
```

```
create table requested_film (  
    film_id serial primary key,  
    title character varying(255) not null,  
    rating mpaa_rating default 'G'::mpaa_rating  
);
```

# Merge

```
insert into requested_film (title, rating)
values
  ('ACADEMY DINOSAUR', 'PG'),
  ('ACE GOLDFINGER', 'G'),
  ('JUST FOR MERGE DEMO', 'NC-17'),
  ('TOO VIOLENT MOVIE', 'R');
```

```
select title from requested_film order by title;
```

title	rating
ACADEMY DINOSAUR	PG
ACE GOLDFINGER	G
JUST FOR MERGE DEMO	NC-17
TOO VIOLENT MOVIE	R

# Merge

```
select title, last_update
from film
where title in (
    'ACADEMY DINOSAUR',
    'ACE GOLDFINGER',
    'JUST FOR MERGE DEMO',
    'TOO VIOLENT MOVIE'
);
```

title	number_of_time_requested
ACADEMY DINOSAUR	1
ACE GOLDFINGER	2







# Merge

```
merge into film f
using requested_film rf
  on rf.title = f.title
when matched then
  update set number_of_time_requested = number_of_time_requested + 1
when not matched and rf.rating = 'R'::mpaa_rating then
  do nothing
when not matched then
  insert (title, rating, number_of_time_requested)
  values (rf.title, rf.rating, 1);
```



# Merge

requested\_film

title	rating
ACADEMY DINOSAUR	PG
ACE GOLDFINGER	G
JUST FOR MERGE DEMO	NC-17
TOO VIOLENT MOVIE	R

```
merge into film f
using requested_film rf
on rf.title = f.title
```

film

title	number_of_time_requested
ACADEMY DINOSAUR	1
ACE GOLDFINGER	2





# Merge

```
merge into film f
using requested_film rf
  on rf.title = f.title
when matched then
  update set number_of_time_requested = number_of_time_requested + 1
when not matched and rf.rating = 'R'::mpaa_rating then
  do nothing
when not matched then
  insert (title, rating, number_of_time_requested)
  values (rf.title, rf.rating, 1);
```

# Merge

```
select title, number_of_time_requested
from film
where title in (
    'ACADEMY DINOSAUR',
    'ACE GOLDFINGER',
    'JUST FOR MERGE DEMO',
    'TOO VIOLENT MOVIE'
)
```

title	number_of_time_requested
ACADEMY DINOSAUR	2
ACE GOLDFINGER	3
JUST FOR MERGE DEMO	1



Listen | Notify



# Listen | Notify

```
create or replace function notify_new_film()
returns trigger
language plpgsql
as $$
declare
  channel text := TG_ARGV[0];
begin
  perform (
    with payload as (select NEW.film_id as id, NEW.title as title)
    select pg_notify(channel, row_to_json(payload)::text) from payload
  );
  return null;
end;
$$;
```

```
create trigger notify_clients
after insert on film_with_notification
for each row execute procedure notify_new_film('film.add');
```





# Listen | Notify

```
listen "film.add";
```

Asynchronous notification "film.add" with payload  
{"id":1010,"title":"Speed"}" received from server  
process with PID 161.

Asynchronous notification "film.add" with payload  
{"id":1011,"title":"John Wick"}" received from server  
process with PID 161.

Asynchronous notification "film.add" with payload  
{"id":1012,"title":"Point Break"}" received from server  
process with PID 161.

Asynchronous notification "film.add" with payload  
{"id":1013,"title":"The Devil's Advocate"}" received  
from server process with PID 161.

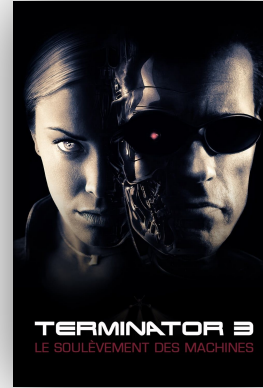
Asynchronous notification "film.add" with payload  
{"id":1014,"title":"The Lake House"}" received from  
server process with PID 161.

```
insert into film_with_notification(title)  
values  
  ('Speed'), ('John Wick'), ('Point Break'),  
  ('The Devil's Advocate'), ('The Lake House');
```

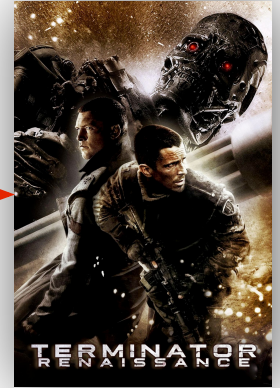
tree & more



# tree & more



# Itree & more





# ltree & more

```
create extension ltree;

create table film_with_saga_order (
    film_id serial primary key,
    title character varying(255) not null,
    saga_order ltree
);

insert into film_with_saga_order (film_id, title, saga_order)
values
    (1, 'Terminator', '1'),
    (2, 'Terminator 2: Judgment Day', '1.2'),
    (3, 'Terminator 3: Rise of the Machines', '1.2.3'),
    (4, 'Terminator Salvation', '1.2.3.4'),
    (5, 'Terminator Genisys', '1.5'),
    (6, 'Terminator: Dark Fate', '1.2.6');
```

# ltree & more

```
with selected_movie as (  
    select saga_order  
    from film_with_saga_order  
    where film_id = 6  
)  
select *  
from film_with_saga_order  
where saga_order @> (select saga_order from selected_movie);  
-- @> means '[left ltree] is ancestor of [right ltree]'
```

film_id	title	saga_order
1	Terminator	1
2	Terminator 2: Judgment Day	1.2
6	Terminator: Dark Fate	1.2.6

Itree & **more**



# ltree & more

```
create table film_with_previous (  
    film_id serial primary key,  
    title character varying(255) not null,  
  
    previous integer references film_with_previous(film_id)  
);
```

```
insert into film_with_previous (film_id, title, previous)  
values  
    (1, 'Terminator', null),  
    (2, 'Terminator 2: Judgment Day', 1),  
    (3, 'Terminator 3: Rise of the Machines', 2),  
    (4, 'Terminator Salvation', 3),  
    (5, 'Terminator Genisys', 1),  
    (6, 'Terminator: Dark Fate', 2);
```



# ltree & more

```
with recursive saga as (  
    select f.film_id, f.title, f.previous  
    from film_with_previous f  
    where f.film_id = 6  
    union all  
    select f.film_id, f.title, f.previous  
    from film_with_previous f  
    inner join saga s on s.previous = f.film_id  
)  
select title  
from saga  
order by film_id;
```

film_id	title	previous
1	Terminator	
2	Terminator 2: Judgment Day	1
6	Terminator: Dark Fate	2





# Foreign Data Wrapper



# Foreign Data Wrapper

```
create extension file_fdw;  
create server file_server foreign data wrapper file_fdw;  
  
create foreign table passwd (  
    username text,  
    pass text,  
    uid int4,  
    gid int4,  
    gecos text,  
    home text,  
    shell text  
) server file_server  
options (format 'text', filename '/etc/passwd', delimiter ':', null '');
```



# Foreign Data Wrapper

```
select *  
from passwd  
where shell ~* '.*bash.*';
```

username	uid	gid	home	shell
root	0	0	/root	/bin/bash
postgres	999	999	/var/lib/postgresql	/bin/bash

# Foreign Data Wrapper

```
create foreign table fs (  
    inode text,  
    block text,  
    permission text,  
    hard_link text,  
    owner text,  
    "group" text,  
    size int,  
    last_modification text,  
    pathname text  
) server file_server  
options (format 'text', program '/list-all-files.sh', delimiter '|', null '');  
  
select pathname, owner, "group", size  
from fs  
where permission ~ '.....rwx'  
order by size desc;
```

pathname	owner	group	size
/etc/alternatives/CREATE_TEXT_SEARCH_CONFIGURATION.7.gz	root	root	71
/etc/alternatives/ALTER_TEXT_SEARCH_CONFIGURATION.7.gz	root	root	70
/etc/alternatives/DROP_TEXT_SEARCH_CONFIGURATION.7.gz	root	root	69
/etc/alternatives/CREATE_TEXT_SEARCH_DICTIONARY.7.gz	root	root	68
/etc/alternatives/ALTER_TEXT_SEARCH_DICTIONARY.7.gz	root	root	67

# Foreign Data Wrapper



# Foreign Data Wrapper

```
create extension postgres_fdw;  
  
create server sakila  
foreign data wrapper postgres_fdw  
options (host 'amazing-pg', port '5432', dbname 'sakila');  
  
create user mapping for postgres  
server sakila  
options (user 'postgres', password 'gjITg2b0033D1bYju27wK2Wo01I2');
```



# Foreign Data Wrapper

```
create foreign table remote_film (  
    film_id integer not null,  
    title character varying(255) not null  
)  
server sakila  
options (schema_name 'public', table_name 'film');  
  
select *  
from remote_film;
```

id		title
-----+-----		
1		ACADEMY DINOSAUR
2		ACE GOLDFINGER
3		ADAPTATION HOLES
4		AFFAIR PREJUDICE
5		AFRICAN EGG

Don't do this!



```
select *  
from film  
where title not in  
      (select * from other_table);
```



```
create table xyz (  
  ...  
) inherits (film)
```





```
create table xyz (  
  date timestamp  
)
```



But use them...



```
create table xyz (  
  id uuid not null default uuid_generate_v4(),  
  title text not null,  
  fts_title tsvector generated always as (to_tsvector('english', title)) stored  
)
```



-- Use *PostGIS* for geo-queries  
create extension **postgis**;





```
create table xyz (  
  json_data jsonb default '{}'  
)
```





 PostgREST

GRAPHJIN



Everywhere!



ND US IT IS THERE WHEN YOU WATCH TELEVISION

THE MATRIX HE IS THERE ONE DREAM WORLD

THE ALL AROUND US IT IS THERE WHEN YOU WATCH TELEVISION

RE WHEN YOU WATCH TELEVISION

のシ品 数量

SHOULD ONE DREAM WORLD NEO AN AGENT TRINITY

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SHOULD ONE DREAM WORLD NEO AN AGENT TRINITY

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In any server...



# In Kubernetes with...



**CloudNativePG**



**yugabyteDB**

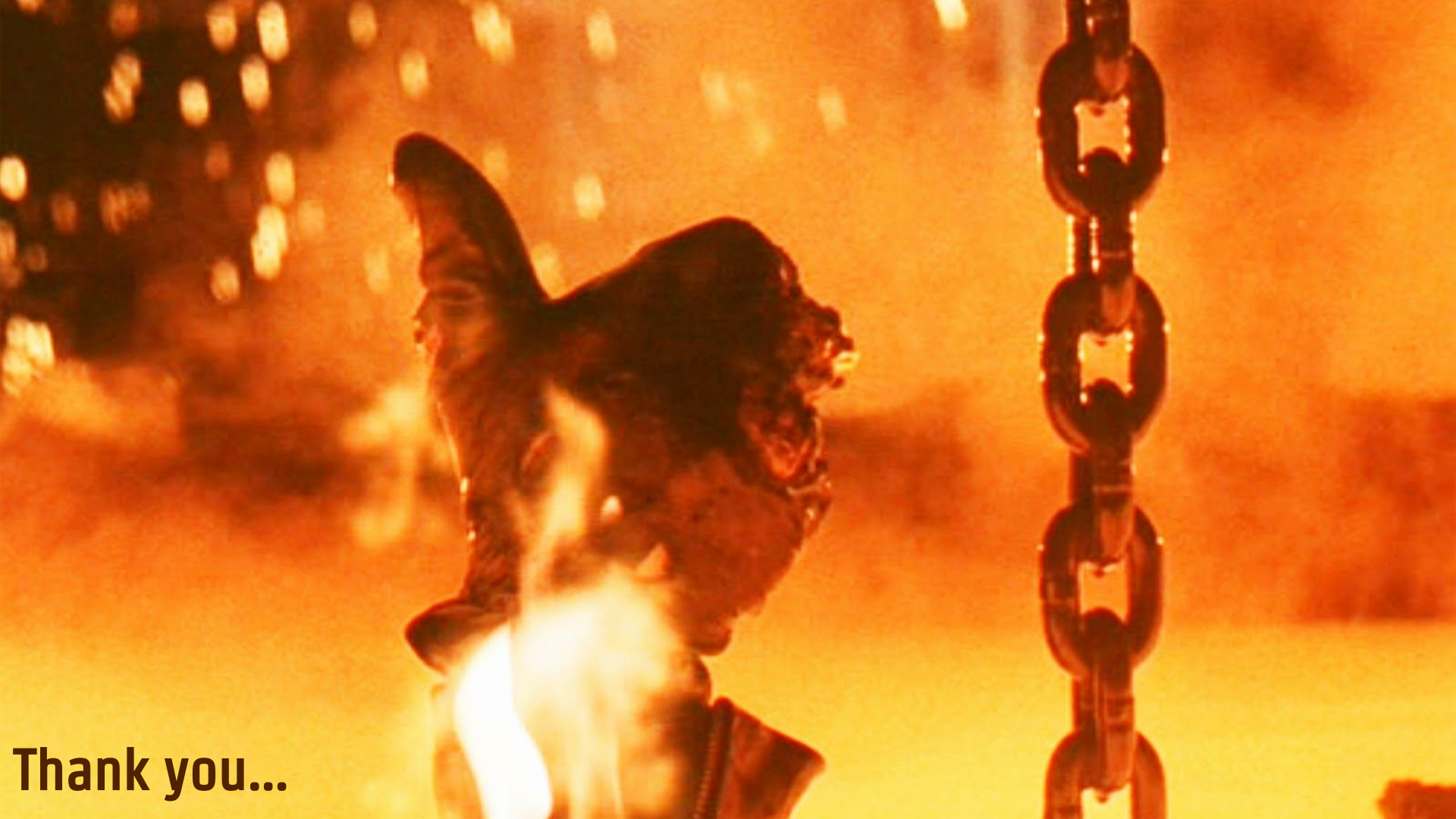








**Infinite possibilities...**



**Thank you...**



# Questions?

X  
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m

