


MySQL: Analysis, understanding, and optimization of queries

Michael Moussa



About Me

- Web application developer for 17 years
- Solutions Architect at  **rackspace**
the #1 managed cloud company
- Zend Expressive maintainer & general open source contributor



5.7

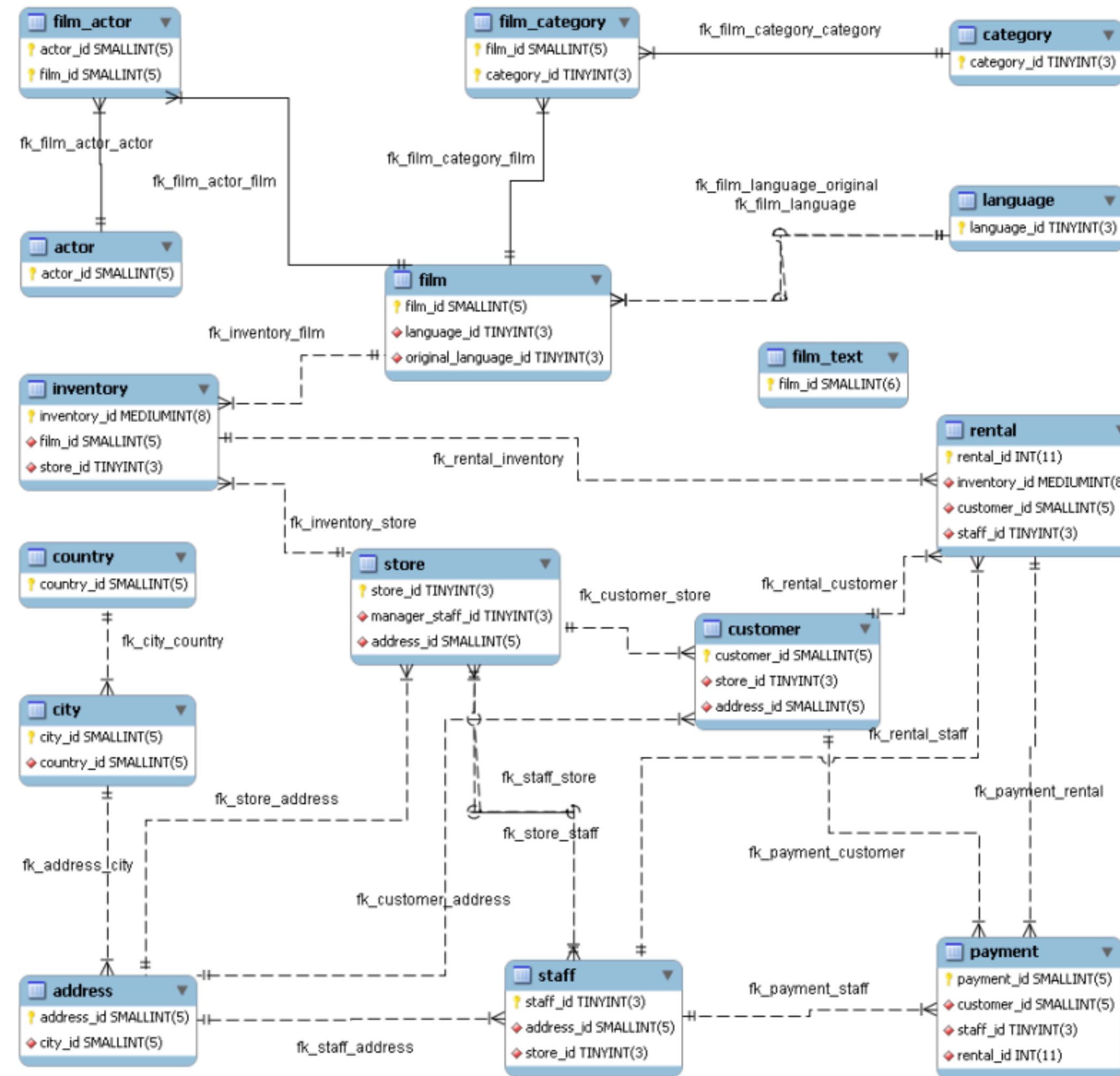
<https://dev.mysql.com/downloads/mysql/>

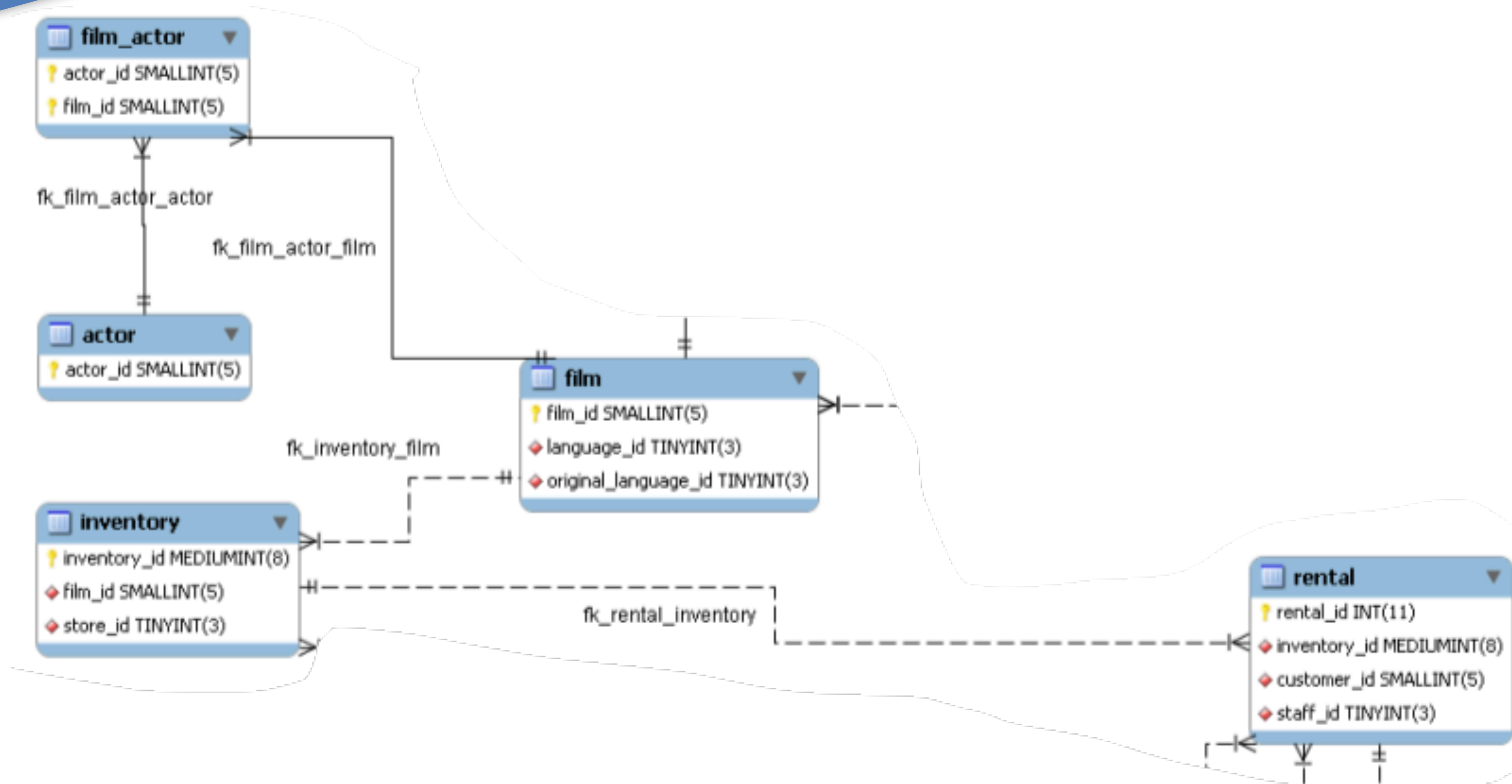
Sakila Sample Database

```
mysql> SOURCE /path/to/sakila-schema.sql
```

```
mysql> SOURCE /path/to/sakila-data.sql
```

<https://dev.mysql.com/doc/sakila/en/>





```
SELECT * FROM film
WHERE rating = 'PG-13'
ORDER BY title;
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- How large is the table?

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- How large is the table?
- How good is the server?


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SELECT * FROM film  
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- How large is the table?
- How good is the server?
- How many users?

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???

Query Execution Plan

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```

id	select_id	table	partitions	type	range	ref	eq_ref	index	key_len	usedcols	rows	filtered	cost
1	1	film	1	ALL					0	1	1	100	1.00
2	1	film	1	ALL					0	1	1	100	1.00
3	1	film	1	ALL					0	1	1	100	1.00
4	1	film	1	ALL					0	1	1	100	1.00
5	1	film	1	ALL					0	1	1	100	1.00
6	1	film	1	ALL					0	1	1	100	1.00
7	1	film	1	ALL					0	1	1	100	1.00
8	1	film	1	ALL					0	1	1	100	1.00
9	1	film	1	ALL					0	1	1	100	1.00
10	1	film	1	ALL					0	1	1	100	1.00
11	1	film	1	ALL					0	1	1	100	1.00
12	1	film	1	ALL					0	1	1	100	1.00
13	1	film	1	ALL					0	1	1	100	1.00
14	1	film	1	ALL					0	1	1	100	1.00
15	1	film	1	ALL					0	1	1	100	1.00
16	1	film	1	ALL					0	1	1	100	1.00
17	1	film	1	ALL					0	1	1	100	1.00
18	1	film	1	ALL					0	1	1	100	1.00
19	1	film	1	ALL					0	1	1	100	1.00
20	1	film	1	ALL					0	1	1	100	1.00
21	1	film	1	ALL					0	1	1	100	1.00
22	1	film	1	ALL					0	1	1	100	1.00
23	1	film	1	ALL					0	1	1	100	1.00
24	1	film	1	ALL					0	1	1	100	1.00
25	1	film	1	ALL					0	1	1	100	1.00
26	1	film	1	ALL					0	1	1	100	1.00
27	1	film	1	ALL					0	1	1	100	1.00
28	1	film	1	ALL					0	1	1	100	1.00
29	1	film	1	ALL					0	1	1	100	1.00
30	1	film	1	ALL					0	1	1	100	1.00
31	1	film	1	ALL					0	1	1	100	1.00
32	1	film	1	ALL					0	1	1	100	1.00
33	1	film	1	ALL					0	1	1	100	1.00
34	1	film	1	ALL					0	1	1	100	1.00
35	1	film	1	ALL					0	1	1	100	1.00
36	1	film	1	ALL					0	1	1	100	1.00
37	1	film	1	ALL					0	1	1	100	1.00
38	1	film	1	ALL					0	1	1	100	1.00
39	1	film	1	ALL					0	1	1	100	1.00
40	1	film	1	ALL					0	1	1	100	1.00
41	1	film	1	ALL					0	1	1	100	1.00
42	1	film	1	ALL					0	1	1	100	1.00
43	1	film	1	ALL					0	1	1	100	1.00
44	1	film	1	ALL					0	1	1	100	1.00
45	1	film	1	ALL					0	1	1	100	1.00
46	1	film	1	ALL					0	1	1	100	1.00
47	1	film	1	ALL					0	1	1	100	1.00
48	1	film	1	ALL					0	1	1	100	1.00
49	1	film	1	ALL					0	1	1	100	1.00
50	1	film	1	ALL					0	1	1	100	1.00
51	1	film	1	ALL					0	1	1	100	1.00
52	1	film	1	ALL					0	1	1	100	1.00
53	1	film	1	ALL					0	1	1	100	1.00
54	1	film	1	ALL					0	1	1	100	1.00
55	1	film	1	ALL					0	1	1	100	1.00
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57	1	film	1	ALL					0	1	1	100	1.00
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59	1	film	1	ALL					0	1	1	100	1.00
60	1	film	1	ALL					0	1	1	100	1.00
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62	1	film	1	ALL					0	1	1	100	1.00
63	1	film	1	ALL					0	1	1	100	1.00
64	1	film	1	ALL					0	1	1	100	1.00
65	1	film	1	ALL					0	1	1	100	1.00
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67	1	film	1	ALL					0	1	1	100	1.00
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70	1	film	1	ALL					0	1	1	100	1.00
71	1	film	1	ALL					0	1	1	100	1.00
72	1	film	1	ALL					0	1	1	100	1.00
73	1	film	1	ALL					0	1	1	100	1.00
74	1	film	1	ALL					0	1	1	100	1.00
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77	1	film	1	ALL					0	1	1	100	1.00
78	1	film	1	ALL					0	1	1	100	1.00
79	1	film	1	ALL					0	1	1	100	1.00
80	1	film	1	ALL					0	1	1	100	1.00
81	1	film	1	ALL					0	1	1	100	1.00
82	1	film	1	ALL					0	1	1	100	1.00
83	1	film	1	ALL					0	1	1	100	1.00
84	1	film	1	ALL					0	1	1	100	1.00
85	1	film	1	ALL					0	1	1	100	1.00
86	1	film	1	ALL					0	1	1	100	1.00
87	1	film	1	ALL					0	1	1	100	1.00
88	1	film	1	ALL					0	1	1	100	1.00
89	1	film	1	ALL					0	1	1	100	1.00
90	1	film	1	ALL					0	1	1	100	1.00
91	1	film	1	ALL					0	1	1	100	1.00
92	1	film	1	ALL					0	1	1	100	1.00
93	1	film	1	ALL					0	1	1	100	1.00
94	1	film	1	ALL					0	1	1	100	1.00
95	1	film	1	ALL					0	1	1	100	1.00
96	1	film	1	ALL					0	1	1	100	1.00
97	1	film	1	ALL					0	1	1	100	1.00
98	1	film	1	ALL					0	1	1	100	1.00
99	1	film	1	ALL					0	1	1	100	1.00
100	1	film	1	ALL					0	1	1	100	1.00

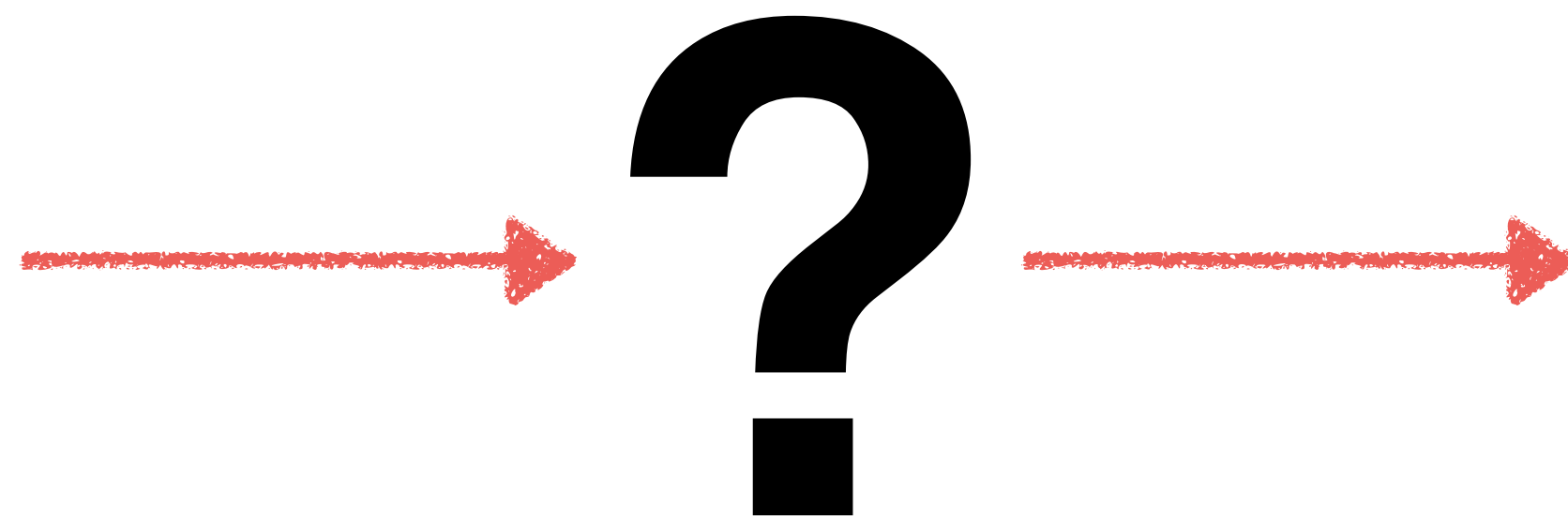
Query Execution Plan

```
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```

[illegible]

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```
SELECT * FROM film
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```



1	John Doe	john.doe@example.com	555-123-4567	123 Main St	New York	NY	10001	USA	2023-10-27	10:30	Active	Initial contact	View
2	Jane Smith	jane.smith@example.com	555-234-5678	456 Elm St	Los Angeles	CA	90001	USA	2023-10-27	11:00	Active	Follow up	View
3	Bob Johnson	bob.johnson@example.com	555-345-6789	789 Oak St	Chicago	IL	60601	USA	2023-10-27	11:30	Active	Meeting	View
4	Alice Brown	alice.brown@example.com	555-456-7890	101 Pine St	San Francisco	CA	94101	USA	2023-10-27	12:00	Active	Call	View
5	Charlie Davis	charlie.davis@example.com	555-567-8901	202 Cedar St	Phoenix	AZ	85001	USA	2023-10-27	12:30	Active	Email	View
6	Diana Prince	diana.prince@example.com	555-678-9012	303 Maple St	Philadelphia	PA	19101	USA	2023-10-27	13:00	Active	Meeting	View
7	Frank Miller	frank.miller@example.com	555-789-0123	404 Birch St	San Diego	CA	92101	USA	2023-10-27	13:30	Active	Call	View
8	Grace Lee	grace.lee@example.com	555-890-1234	505 Walnut St	Seattle	WA	98101	USA	2023-10-27	14:00	Active	Email	View
9	Henry Wilson	henry.wilson@example.com	555-901-2345	606 Cherry St	Portland	OR	97201	USA	2023-10-27	14:30	Active	Meeting	View
10	Ivy Green	ivy.green@example.com	555-012-3456	707 Elm St	Denver	CO	80201	USA	2023-10-27	15:00	Active	Call	View
11	Jack Black	jack.black@example.com	555-123-4567	808 Oak St	San Jose	CA	95101	USA	2023-10-27	15:30	Active	Email	View
12	Karen White	karen.white@example.com	555-234-5678	909 Pine St	Austin	TX	78701	USA	2023-10-27	16:00	Active	Meeting	View
13	Liam King	liam.king@example.com	555-345-6789	1010 Maple St	San Antonio	TX	78201	USA	2023-10-27	16:30	Active	Call	View
14	Mia Queen	mia.queen@example.com	555-456-7890	1111 Birch St	Fort Worth	TX	76101	USA	2023-10-27	17:00	Active	Email	View
15	Noah Scott	noah.scott@example.com	555-567-8901	1212 Walnut St	Columbus	OH	43201	USA	2023-10-27	17:30	Active	Meeting	View
16	Olivia Adams	olivia.adams@example.com	555-678-9012	1313 Cherry St	Indianapolis	IN	46201	USA	2023-10-27	18:00	Active	Call	View
17	Peter Hall	peter.hall@example.com	555-789-0123	1414 Elm St	San Francisco	CA	94101	USA	2023-10-27	18:30	Active	Email	View
18	Quinn King	quinn.king@example.com	555-890-1234	1515 Oak St	San Francisco	CA	94101	USA	2023-10-27	19:00	Active	Meeting	View
19	Rachel Green	rachel.green@example.com	555-901-2345	1616 Pine St	San Francisco	CA	94101	USA	2023-10-27	19:30	Active	Call	View
20	Samuel White	samuel.white@example.com	555-012-3456	1717 Maple St	San Francisco	CA	94101	USA	2023-10-27	20:00	Active	Email	View
21	Tina Black	tina.black@example.com	555-123-4567	1818 Birch St	San Francisco	CA	94101	USA	2023-10-27	20:30	Active	Meeting	View
22	Uma Brown	uma.brown@example.com	555-234-5678	1919 Walnut St	San Francisco	CA	94101	USA	2023-10-27	21:00	Active	Call	View
23	Victor King	victor.king@example.com	555-345-6789	2020 Cherry St	San Francisco	CA	94101	USA	2023-10-27	21:30	Active	Email	View
24	Wendy Queen	wendy.queen@example.com	555-456-7890	2121 Elm St	San Francisco	CA	94101	USA	2023-10-27	22:00	Active	Meeting	View
25	Xavier Scott	xavier.scott@example.com	555-567-8901	2222 Oak St	San Francisco	CA	94101	USA	2023-10-27	22:30	Active	Call	View
26	Yara Adams	yara.adams@example.com	555-678-9012	2323 Pine St	San Francisco	CA	94101	USA	2023-10-27	23:00	Active	Email	View
27	Zoe Hall	zoe.hall@example.com	555-789-0123	2424 Maple St	San Francisco	CA	94101	USA	2023-10-27	23:30	Active	Meeting	View
28	Adam King	adam.king@example.com	555-890-1234	2525 Birch St	San Francisco	CA	94101	USA	2023-10-27	00:00	Active	Call	View
29	Bella Queen	bella.queen@example.com	555-901-2345	2626 Walnut St	San Francisco	CA	94101	USA	2023-10-27	00:30	Active	Email	View
30	Carl Scott	carl.scott@example.com	555-012-3456	2727 Cherry St	San Francisco	CA	94101	USA	2023-10-27	01:00	Active	Meeting	View
31	Dora Adams	dora.adams@example.com	555-123-4567	2828 Elm St	San Francisco	CA	94101	USA	2023-10-27	01:30	Active	Call	View
32	Ethan King	ethan.king@example.com	555-234-5678	2929 Oak St	San Francisco	CA	94101	USA	2023-10-27	02:00	Active	Email	View
33	Fiona Queen	fiona.queen@example.com	555-345-6789	3030 Pine St	San Francisco	CA	94101	USA	2023-10-27	02:30	Active	Meeting	View
34	George Scott	george.scott@example.com	555-456-7890	3131 Maple St	San Francisco	CA	94101	USA	2023-10-27	03:00	Active	Call	View
35	Hannah Adams	hannah.adams@example.com	555-567-8901	3232 Birch St	San Francisco	CA	94101	USA	2023-10-27	03:30	Active	Email	View
36	Ian Hall	ian.hall@example.com	555-678-9012	3333 Walnut St	San Francisco	CA	94101	USA	2023-10-27	04:00	Active	Meeting	View
37	Jessica King	jessica.king@example.com	555-789-0123	3434 Cherry St	San Francisco	CA	94101	USA	2023-10-27	04:30	Active	Call	View
38	Kyle Queen	kyle.queen@example.com	555-890-1234	3535 Elm St	San Francisco	CA	94101	USA	2023-10-27	05:00	Active	Email	View
39	Laura Scott	laura.scott@example.com	555-901-2345	3636 Oak St	San Francisco	CA	94101	USA	2023-10-27	05:30	Active	Meeting	View
40	Mason Adams	mason.adams@example.com	555-012-3456	3737 Pine St	San Francisco	CA	94101	USA	2023-10-27	06:00	Active	Call	View
41	Nora Hall	nora.hall@example.com	555-123-4567	3838 Maple St	San Francisco	CA	94101	USA	2023-10-27	06:30	Active	Email	View
42	Oliver King	oliver.king@example.com	555-234-5678	3939 Birch St	San Francisco	CA	94101	USA	2023-10-27	07:00	Active	Meeting	View
43	Pamela Queen	pamela.queen@example.com	555-345-6789	4040 Walnut St	San Francisco	CA	94101	USA	2023-10-27	07:30	Active	Call	View
44	Quinn Scott	quinn.scott@example.com	555-456-7890	4141 Cherry St	San Francisco	CA	94101	USA	2023-10-27	08:00	Active	Email	View
45	Rachel Adams	rachel.adams@example.com	555-567-8901	4242 Elm St	San Francisco	CA	94101	USA	2023-10-27	08:30	Active	Meeting	View
46	Samuel Hall	samuel.hall@example.com	555-678-9012	4343 Oak St	San Francisco	CA	94101	USA	2023-10-27	09:00	Active	Call	View
47	Tina King	tina.king@example.com	555-789-0123	4444 Pine St	San Francisco	CA	94101	USA	2023-10-27	09:30	Active	Email	View
48	Uma Queen	uma.queen@example.com	555-890-1234	4545 Maple St	San Francisco	CA	94101	USA	2023-10-27	10:00	Active	Meeting	View
49	Victor Scott	victor.scott@example.com	555-901-2345	4646 Birch St	San Francisco	CA	94101	USA	2023-10-27	10:30	Active	Call	View
50	Wendy Adams	wendy.adams@example.com	555-012-3456	4747 Walnut St	San Francisco	CA	94101	USA	2023-10-27	11:00	Active	Email	View
51	Xavier Hall	xavier.hall@example.com	555-123-4567	4848 Cherry St	San Francisco	CA	94101	USA	2023-10-27	11:30	Active	Meeting	View
52	Yara King	yara.king@example.com	555-234-5678	4949 Elm St	San Francisco	CA	94101	USA	2023-10-27	12:00	Active	Call	View
53	Zoe Queen	zoe.queen@example.com	555-345-6789	5050 Oak St	San Francisco	CA	94101	USA	2023-10-27	12:30	Active	Email	View
54	Adam Scott	adam.scott@example.com	555-456-7890	5151 Pine St	San Francisco	CA	94101	USA	2023-10-27	13:00	Active	Meeting	View
55	Bella Adams	bella.adams@example.com	555-567-8901	5252 Maple St	San Francisco	CA	94101	USA	2023-10-27	13:30	Active	Call	View
56	Carl Hall	carl.hall@example.com	555-678-9012	5353 Birch St	San Francisco	CA	94101	USA	2023-10-27	14:00	Active	Email	View
57	Dora King	dora.king@example.com	555-789-0123	5454 Walnut St	San Francisco	CA	94101	USA	2023-10-27	14:30	Active	Meeting	View
58	Ethan Queen	ethan.queen@example.com	555-890-1234	5555 Cherry St	San Francisco	CA	94101	USA	2023-10-27	15:00	Active	Call	View
59	Fiona Scott	fiona.scott@example.com	555-901-2345	5656 Elm St	San Francisco	CA	94101	USA	2023-10-27	15:30	Active	Email	View
60	George Adams	george.adams@example.com	555-012-3456	5757 Oak St	San Francisco	CA	94101	USA	2023-10-27	16:00	Active	Meeting	View
61	Hannah Hall	hannah.hall@example.com	555-123-4567	5858 Pine St	San Francisco	CA	94101	USA	2023-10-27	16:30	Active	Call	View
62	Ian King	ian.king@example.com	555-234-5678	5959 Maple St	San Francisco	CA	94101	USA	2023-10-27	17:00	Active	Email	View
63	Jessica Queen	jessica.queen@example.com	555-345-6789	6060 Birch St	San Francisco	CA	94101	USA	2023-10-27	17:30	Active	Meeting	View
64	Kyle Scott	kyle.scott@example.com	555-456-7890	6161 Walnut St	San Francisco	CA	94101	USA	2023-10-27	18:00	Active	Call	View
65	Laura Adams	laura.adams@example.com	555-567-8901	6262 Cherry St	San Francisco	CA	94101	USA	2023-10-27	18:30	Active	Email	View
66	Mason Hall	mason.hall@example.com	555-678-9012	6363 Elm St	San Francisco	CA	94101	USA	2023-10-27	19:00	Active	Meeting	View
67	Nora King	nora.king@example.com	555-789-0123	6464 Oak St	San Francisco	CA	94101	USA	2023-10-27	19:30	Active	Call	View
68	Oliver Queen	oliver.queen@example.com	555-890-1234	6565 Pine St	San Francisco	CA	94101	USA	2023-10-27	20:00	Active	Email	View
69	Pamela Scott	pamela.scott@example.com	555-901-2345	6666 Maple St	San Francisco	CA	94101	USA	2023-10-27	20:30	Active	Meeting	View
70	Quinn Adams	quinn.adams@example.com	555-012-3456	6767 Birch St	San Francisco	CA	94101	USA	2023-10-27	21:00	Active	Call	View
71	Rachel Hall	rachel.hall@example.com	555-123-4567	6868 Walnut St	San Francisco	CA	94101	USA	2023-10-27	21:30	Active	Email	View
72	Samuel King	samuel.king@example.com	555-234-5678	6969 Cherry St	San Francisco	CA	94101	USA	2023-10-27	22:00	Active	Meeting	View
73	Tina Queen	tina.queen@example.com	555-345-6789	7070 Elm St	San Francisco	CA	94101	USA	2023-10-27	22:30	Active	Call	View
74	Uma Scott	uma.scott@example.com	555-456-7890	7171 Oak St	San Francisco	CA	94101	USA	2023-10-27	23:00	Active	Email	View
75	Victor Adams	victor.adams@example.com	555-567-8901	7272 Pine St	San Francisco	CA	94101	USA	2023-10-27	23:30	Active	Meeting	View
76	Wendy Hall	wendy.hall@example.com	555-678-9012	7373 Maple St	San Francisco	CA	94101	USA	2023-10-27	00:00	Active	Call	View
77	Xavier King	xavier.king@example.com	555-789-0123	7474 Birch St	San Francisco	CA	94101	USA	2023-10-27	00:30	Active	Email	View
78	Yara Queen	yara.queen@example.com	555-890-1234	7575 Walnut St	San Francisco	CA	94101	USA	2023-10-27	01:00	Active	Meeting	View
79	Zoe Scott	zoe.scott@example.com	555-901-2345	7676 Cherry St	San Francisco	CA	94101	USA	2023-10-27	01:30	Active	Call	View
80	Adam Adams	adam.adams@example.com	555-012-3456	7777 Elm St	San Francisco	CA	94101	USA	2023-10-27	02:00	Active	Email	View
81	Bella Hall	bella.hall@example.com	555-123-4567	7878 Oak St	San Francisco	CA	94101	USA	2023-10-27	02:30	Active	Meeting	View
82	Carl King	carl.king@example.com	555-234-5678	7979 Pine St	San Francisco	CA	94101	USA	2023-10-27	03:00	Active	Call	View
83	Dora Queen	dora.queen@example.com	555-345-6789	8080 Maple St	San Francisco	CA	94101	USA	2023-10-27	03:30	Active	Email	View
84	Ethan Scott	ethan.scott@example.com	555-456-7890	8181 Birch St	San Francisco	CA	94101	USA	2023-10-27	04:00	Active	Meeting	View
85	Fiona Adams	fiona.adams@example.com	555-567-8901	8282 Walnut St	San Francisco	CA	94101	USA	2023-10-27	04:30	Active	Call	View
86	George Hall	george.hall@example.com	555-678-9012	8383 Cherry St	San Francisco	CA	94101	USA	2023-10-27	05:00	Active	Email	View
87	Hannah King	hannah.king@example.com	555-789-0123	8484 Elm St	San Francisco	CA	94101	USA	2023-10-27	05:30	Active	Meeting	View
88	Ian Queen	ian.queen@example.com	555-890-1234	8585 Oak St	San Francisco	CA	94101	USA	2023-10-27	06:00	Active	Call	View
89	Jessica Scott	jessica.scott@example.com	555-901-2345	8686 Pine St	San Francisco	CA	94101	USA	2023-10-27	06:30	Active	Email	View
90	Kyle Adams	kyle.adams@example.com	555-012-3456	8787 Maple St	San Francisco	CA	94101	USA	2023-10-27	07:00	Active	Meeting	View
91	Laura Hall	laura.hall@example.com	555-123-4567	8888 Birch St	San Francisco	CA	94101	USA	2023-10-27	07:30	Active	Call	View
92	Mason King	mason.king@example.com	555-234-5678	8989 Walnut St	San Francisco	CA	94101	USA	2023-10-27	08:00	Active	Email	View
93	Nora Queen	nora.queen@example.com	555-345-6789	9090 Cherry St	San Francisco	CA	94101	USA	2023-10-27	08:30	Active	Meeting	View
94	Oliver Scott	oliver.scott@example.com	555-456-7890	9191 Elm St	San Francisco	CA	94101	USA	2023-10-27	09:00	Active	Call	View
95	Pamela Adams	pamela.adams@example.com	555-567-8901	9292 Oak St	San Francisco	CA	94101	USA	2023-10-27	09:30	Active	Email	View
96	Quinn Hall	quinn.hall@example.com	555-678-9012	9393 Pine St	San Francisco	CA	94101	USA	2023-10-27	10:00	Active	Meeting	View
97	Rachel King	rachel.king@example.com	555-789-0123	9494 Maple St	San Francisco	CA	94101	USA</					

```
SELECT * FROM film
WHERE rating = 'PG-13'
ORDER BY title;
```



```
EXPLAIN SELECT * FROM film
WHERE rating = 'PG-13'
ORDER BY title;
```

id	select_type	table	partitions	type	possible_keys	key	key_len	ref	rows	filtered	Extra
1	SIMPLE	film	NULL	ALL	NULL	NULL	NULL	NULL	1000	20.00	Using where; Using filesort

+	-	-	-	+
		id		
+	-	-	-	+
		1		
+	-	-	-	+

+-----+

select_type
SIMPLE

+-----+

table

film

partitions
NULL

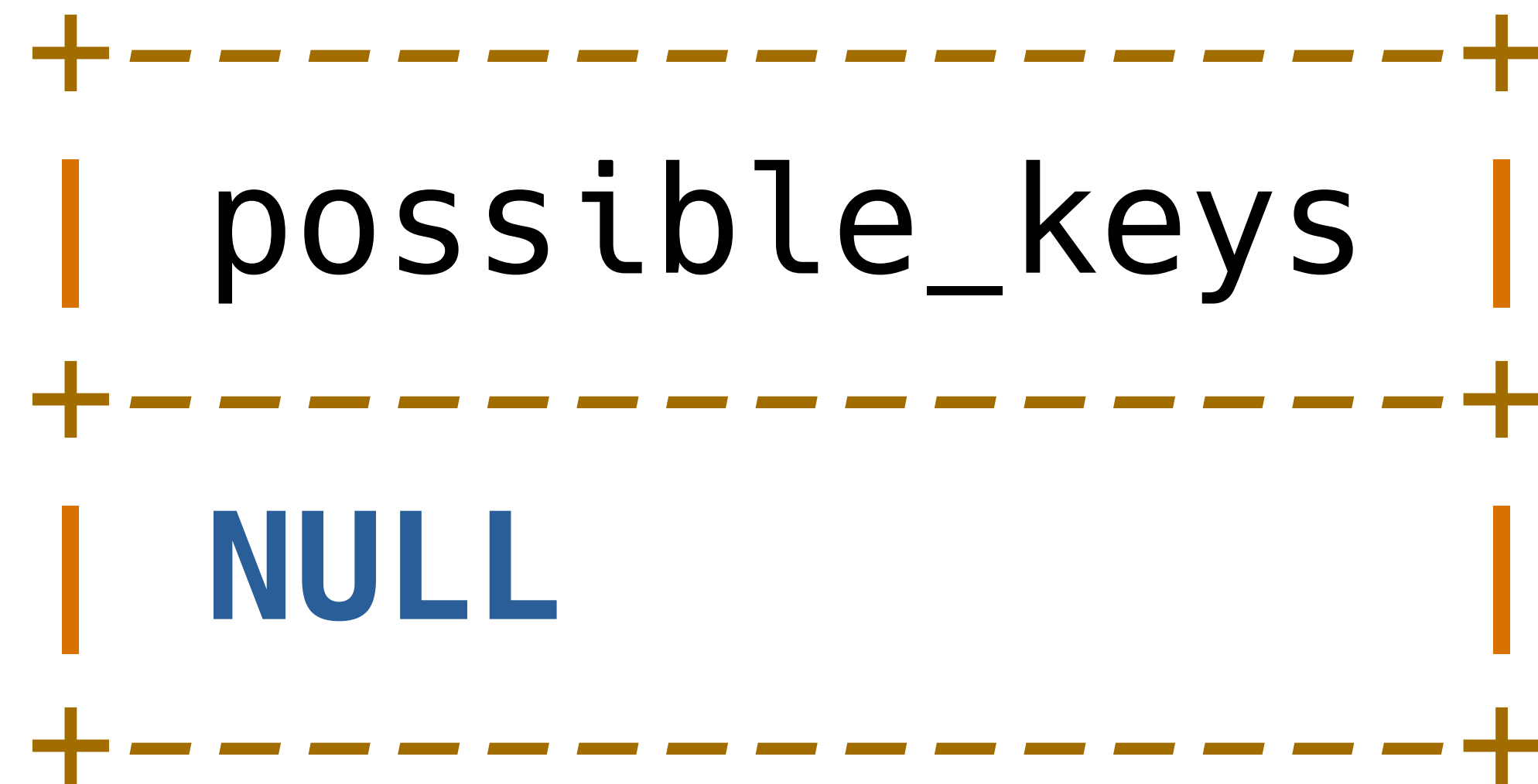
+-----+

| type |

+-----+

| ALL |

+-----+



possible_keys
NULL

A diagram representing a table with two rows. The first row contains the word 'key' and the second row contains the word 'NULL'. The table is enclosed in a dashed orange border with plus signs at the corners. The text 'key' and 'NULL' is in blue.

key
NULL

key_len
NULL

A diagram of a table with two rows. The first row contains the text 'ref' and the second row contains the text 'NULL'. The table is enclosed in a dashed border with plus signs at the corners. The text is in a blue font.

ref
NULL

+ - - - - +
| rows |
+ - - - - +
| 1000 |
+ - - - - +

+	-	-	-	-	-	-	-	+
+	-	-	-	-	-	-	-	+
+	-	-	-	-	-	-	-	+

+-----+

| Extra |

+-----+

| Using where; Using filesort |

+-----+

id	select_type	table	partitions	type	possible_keys	key	key_len	ref	rows	filtered	Extra
1	SIMPLE	film	NULL	ALL	NULL	NULL	NULL	NULL	1000	20.00	Using where; Using filesort

id	select_type	table	partitions	type	possible_keys	key	key_len	ref	rows	filtered	Extra
1	SIMPLE	film	NULL	ALL	NULL	NULL	NULL	NULL	1000	20.00	Using where; Using filesort

id	select_type	table	partitions	type	possible_keys	key	key_len	ref	rows	filtered	Extra
1	SIMPLE	film	NULL	ALL	NULL	NULL	NULL	NULL	1000	20.00	Using where; Using filesort

type	possible_keys	key	key_len	ref
ALL	NULL	NULL	NULL	NULL

rows	Extra
1000	Using where; Using filesort

type	possible_keys	key	key_len	ref
ALL	NULL	NULL	NULL	NULL

rows	Extra
1000	Using where; Using filesort

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1	Franco, Karen	Ap #755-4742 Facilisis St.	Springfield	MO	43416	(106) 849-6533
2	Spears, Kasper	P.O. Box 735, 4334 Odio Av.	Chesapeake	VA	98479	(575) 628-4700
3	Hammond, Eagan	Ap #144-8093 Sed St.	Ketchikan	AK	99976	(449) 141-4138
4	Snider, Nell	371-9283 Quis Street	Dover	DE	43469	(396) 685-6187
5	Castillo, Warren	Ap #168-6393 Duis Rd.	Helena	MT	55870	(161) 613-0189
6	Wolf, Kaden	Ap #715-9286 Iaculis Rd.	Provo	UT	52417	(629) 431-4616
7	Delacruz, Demetrius	Ap #849-1764 Tortor Road	Lakewood	CO	28653	(822) 996-8301
8	Juarez, Doris	868-7573 Nisi Rd.	Portland	OR	75494	(467) 118-7614
9	Wilder, Nita	Ap #998-9604 Gravida. Road	Oklahoma City	OK	78281	(941) 150-6649
10	Contreras, Zeus	P.O. Box 331, 7240 Mi Street	Mesa	AZ	85355	(328) 770-3052
11	Hale, Deborah	9894 Blandit St.	Evansville	IN	58950	(984) 274-5023
12	Simon, Christopher	310-7500 Odio. Ave	Saint Paul	MN	92020	(467) 702-3457
13	Johns, Grady	3624 Id St.	Little Rock	AR	71837	(237) 999-9658
14	Leblanc, Ifeoma	410-7139 Aliquam, Rd.	Hillsboro	OR	28131	(718) 104-3022
15	Tyson, Zeph	5159 Ac Avenue	Covington	KY	65803	(736) 889-3502
16	Mckenzie, Mercedes	P.O. Box 344, 8895 Ridiculus St.	Olathe	KS	71691	(503) 884-5285
17	Baxter, Nelle	924-9300 Fames Av.	Houston	TX	21327	(713) 684-9391
18	Keller, Elaine	594-3184 Dapibus Rd.	Gillette	WY	43817	(494) 518-0997
19	Logan, Alec	Ap #560-6087 Id St.	Phoenix	AZ	86132	(184) 507-3231
20	Christensen, Mona	P.O. Box 948, 3731 Dui Avenue	Virginia Beach	VA	73884	(469) 792-9473

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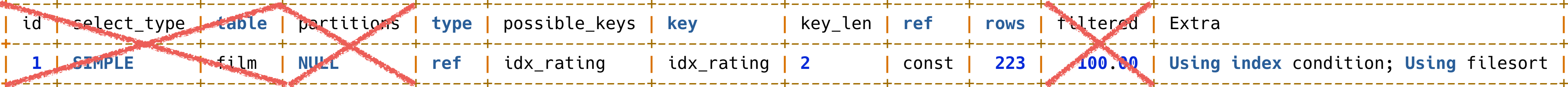
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17	Baxter, Nelle	924-9300 Fames Av.	Houston	TX	21327	(713) 684-9391
18	Keller, Elaine	594-3184 Dapibus Rd.	Gillette	WY	43817	(494) 518-0997
19	Logan, Alec	Ap #560-6087 Id St.	Phoenix	AZ	86132	(184) 507-3231
20	Christensen, Mona	P.O. Box 948, 3731 Dui Avenue	Virginia Beach	VA	73884	(469) 792-9473

id	name	street_address	city	state	zip_code	phone
1	Franco, Karen	Ap #755-4742 Facilisis St.	Springfield	MO	43416	(106) 849-6533
2	Spears, Kasper	P.O. Box 735, 4334 Odio Av.	Chesapeake	VA	98479	(575) 628-4700
3	Hammond, Eagan	Ap #144-8093 Sed St.	Ketchikan	AK	99976	(449) 141-4138
4	Snider, Nell	371-9283 Quis Street	Dover	DE	43469	(396) 685-6187
5	Castillo, Warren	Ap #168-6393 Duis Rd.	Helena	MT	55870	(161) 613-0189
6	Wolf, Kaden	Ap #715-9286 Iaculis Rd.	Provo	UT	52417	(629) 431-4616
7	Delacruz, Demetrius	Ap #849-1764 Tortor Road	Lakewood	CO	28653	(822) 996-8301
8	Juarez, Doris	868-7573 Nisi Rd.	Portland	OR	75494	(467) 118-7614
9	Wilder, Nita	Ap #998-9604 Gravida. Road	Oklahoma City	OK	78281	(941) 150-6649
10	Contreras, Zeus	P.O. Box 331, 7240 Mi Street	Mesa	AZ	85355	(328) 770-3052
11	Hale, Deborah	9894 Blandit St.	Evansville	IN	58950	(984) 274-5023
12	Simon, Christopher	310-7500 Odio. Ave	Saint Paul	MN	92020	(467) 702-3457
13	Johns, Grady	3624 Id St.	Little Rock	AR	71837	(237) 999-9658
14	Leblanc, Ifeoma	410-7139 Aliquam, Rd.	Hillsboro	OR	28131	(718) 104-3022
15	Tyson, Zeph	5159 Ac Avenue	Covington	KY	65803	(736) 889-3502
16	Mckenzie, Mercedes	P.O. Box 344, 8895 Ridiculus St.	Olathe	KS	71691	(503) 884-5285
17	Baxter, Nelle	924-9300 Fames Av.	Houston	TX	21327	(713) 684-9391
18	Keller, Elaine	594-3184 Dapibus Rd.	Gillette	WY	43817	(494) 518-0997
19	Logan, Alec	Ap #560-6087 Id St.	Phoenix	AZ	86132	(184) 507-3231
20	Christensen, Mona	P.O. Box 948, 3731 Dui Avenue	Virginia Beach	VA	73884	(469) 792-9473

```
CREATE INDEX idx_rating  
ON film(rating);
```


id	select_type	table	partitions	type	possible_keys	key	key_len	ref	rows	filtered	Extra
1	SIMPLE	film	NULL	ref	idx_rating	idx_rating	2	const	223	100.00	Using index condition; Using filesort



id	select_type	table	partitions	type	possible_keys	key	key_len	ref	rows	filtered	Extra
1	SIMPLE	film	NULL	ref	idx_rating	idx_rating	2	const	223	100.00	Using index condition; Using filesort

type	possible_keys	key	key_len	ref
ref	idx_rating	idx_rating	2	const

rows	Extra
223	Using index condition; Using filesort

type	possible_keys	key	key_len	ref
ref	idx_rating	idx_rating	2	const



rows	Extra
223	Using index condition; Using filesort



type	possible_keys	key	key_len	ref
ref	idx_rating	idx_rating	2	const





rows	Extra
223	Using index condition; Using filesort



type	possible_keys	key	key_len	ref
ref	idx_rating	idx_rating	2	const





rows	Extra
223	Using index condition; Using filesort

type	possible_keys	key	key_len	ref
ref	idx_rating	idx_rating	2	const




rows	Extra
223	Using index condition; Using filesort

type	possible_keys	key	key_len	ref
ref	idx_rating	idx_rating	2	const



rows	Extra
223	Using index condition; Using filesort



type	possible_keys	key	key_len	ref
ref	idx_rating	idx_rating	2	const



rows	Extra			
223	Using index condition; Using filesort			

		✓		✓		✓
type	possible_keys	key	key_len	ref		
ref	idx_rating	idx_rating	2	const		



rows	Extra				
223	Using index condition; Using filesort				

"type"

ALL

index

range

index_subquery

unique_subquery

index_merge

ref_or_null

fulltext

ref

eq_ref

const

system

"type"



ALL

index

range

index_subquery

unique_subquery

index_merge

ref_or_null

fulltext

ref

eq_ref

const

system

"type"

ALL
→ index
range
index_subquery
unique_subquery
index_merge

ref_or_null
fulltext
ref
eq_ref
const
system

id	name
17	Baxter, Nelle
5	Castillo, Warren
20	Christensen, Mona
10	Contreras, Zeus
7	Delacruz, Demetrius
1	Franco, Karen
11	Hale, Deborah
3	Hammond, Eagan
13	Johns, Grady
8	Juarez, Doris
18	Keller, Elaine
14	Leblanc, Ifeoma
19	Logan, Alec
16	Mckenzie, Mercedes
12	Simon, Christopher
4	Snider, Nell
2	Spears, Kasper
15	Tyson, Zeph
9	Wilder, Nita
6	Wolf, Kaden

SELECT name **FROM** person;

SELECT * **FROM** person;

SELECT name, phone **FROM** person;

id	name
17	Baxter, Nelle
5	Castillo, Warren
20	Christensen, Mona
10	Contreras, Zeus
7	Delacruz, Demetrius
1	Franco, Karen
11	Hale, Deborah
3	Hammond, Eagan
13	Johns, Grady
8	Juarez, Doris
18	Keller, Elaine
14	Leblanc, Ifeoma
19	Logan, Alec
16	Mckenzie, Mercedes
12	Simon, Christopher
4	Snider, Nell
2	Spears, Kasper
15	Tyson, Zeph
9	Wilder, Nita
6	Wolf, Kaden

"index"

SELECT name **FROM** person;

SELECT * **FROM** person;

SELECT name, phone **FROM** person;

id	name
17	Baxter, Nelle
5	Castillo, Warren
20	Christensen, Mona
10	Contreras, Zeus
7	Delacruz, Demetrius
1	Franco, Karen
11	Hale, Deborah
3	Hammond, Eagan
13	Johns, Grady
8	Juarez, Doris
18	Keller, Elaine
14	Leblanc, Ifeoma
19	Logan, Alec
16	Mckenzie, Mercedes
12	Simon, Christopher
4	Snider, Nell
2	Spears, Kasper
15	Tyson, Zeph
9	Wilder, Nita
6	Wolf, Kaden

"index"

SELECT name **FROM** person;

SELECT * **FROM** person;

"ALL"

SELECT name, phone **FROM** person;

"type"

ALL
→ index
range
index_subquery
unique_subquery
index_merge

ref_or_null
fulltext
ref
eq_ref
const
system

"type"

ALL

index

→ range

index_subquery

unique_subquery

index_merge

ref_or_null

fulltext

ref

eq_ref

const

system

id	name
17	Baxter, Nelle
5	Castillo, Warren
20	Christensen, Mona
10	Contreras, Zeus
7	Delacruz, Demetrius
1	Franco, Karen
11	Hale, Deborah
3	Hammond, Eagan
13	Johns, Grady
8	Juarez, Doris
18	Keller, Elaine
14	Leblanc, Ifeoma
19	Logan, Alec
16	Mckenzie, Mercedes
12	Simon, Christopher
4	Snider, Nell
2	Spears, Kasper
15	Tyson, Zeph
9	Wilder, Nita
6	Wolf, Kaden

```
SELECT * FROM person
WHERE name BETWEEN 'M' AND 'Z';
```

id	name
17	Baxter, Nelle
5	Castillo, Warren
20	Christensen, Mona
10	Contreras, Zeus
7	Delacruz, Demetrius
1	Franco, Karen
11	Hale, Deborah
3	Hammond, Eagan
13	Johns, Grady
8	Juarez, Doris
18	Keller, Elaine
14	Leblanc, Ifeoma
19	Logan, Alec
16	Mckenzie, Mercedes
12	Simon, Christopher
4	Snider, Nell
2	Spears, Kasper
15	Tyson, Zeph
9	Wilder, Nita
6	Wolf, Kaden

```
SELECT * FROM person
WHERE name BETWEEN 'M' AND 'Z';
```

id	name
17	Baxter, Nelle
5	Castillo, Warren
20	Christensen, Mona
10	Contreras, Zeus
7	Delacruz, Demetrius
1	Franco, Karen
11	Hale, Deborah
3	Hammond, Eagan
13	Johns, Grady
8	Juarez, Doris
18	Keller, Elaine
14	Leblanc, Ifeoma
19	Logan, Alec
16	Mckenzie, Mercedes
12	Simon, Christopher
4	Snider, Nell
2	Spears, Kasper
15	Tyson, Zeph
9	Wilder, Nita
6	Wolf, Kaden

```
SELECT * FROM person
WHERE name BETWEEN 'M' AND 'Z';
```



(>, >=, <, <=, IN(), etc.)

"type"

ALL

index

→ range

index_subquery

unique_subquery

index_merge

ref_or_null

fulltext

ref

eq_ref

const

system

"type"

ALL

index

range

→ index_subquery

→ unique_subquery

index_merge

ref_or_null

fulltext

ref

eq_ref

const

system

"type"

ALL

index

range

index_subquery

unique_subquery

→ index_merge

ref_or_null

fulltext

ref

eq_ref

const

system


```
SELECT film_id, actor_id  
FROM film_actor  
WHERE actor_id = 13 OR film_id = 13;
```

```
SELECT film_id, actor_id  
FROM film_actor  
WHERE actor_id = 13 OR film_id = 13;
```



35 rows

```
SELECT film_id, actor_id  
FROM film_actor  
WHERE actor_id = 13 OR film_id = 13;
```

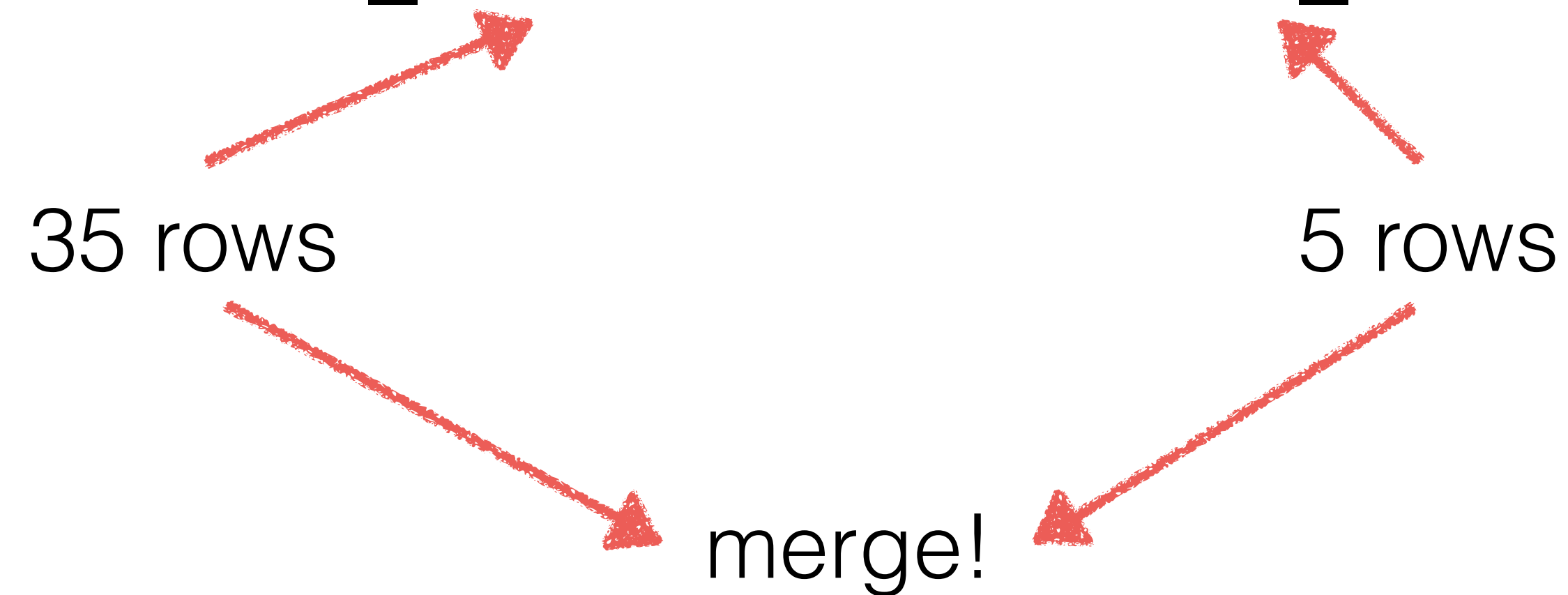


35 rows

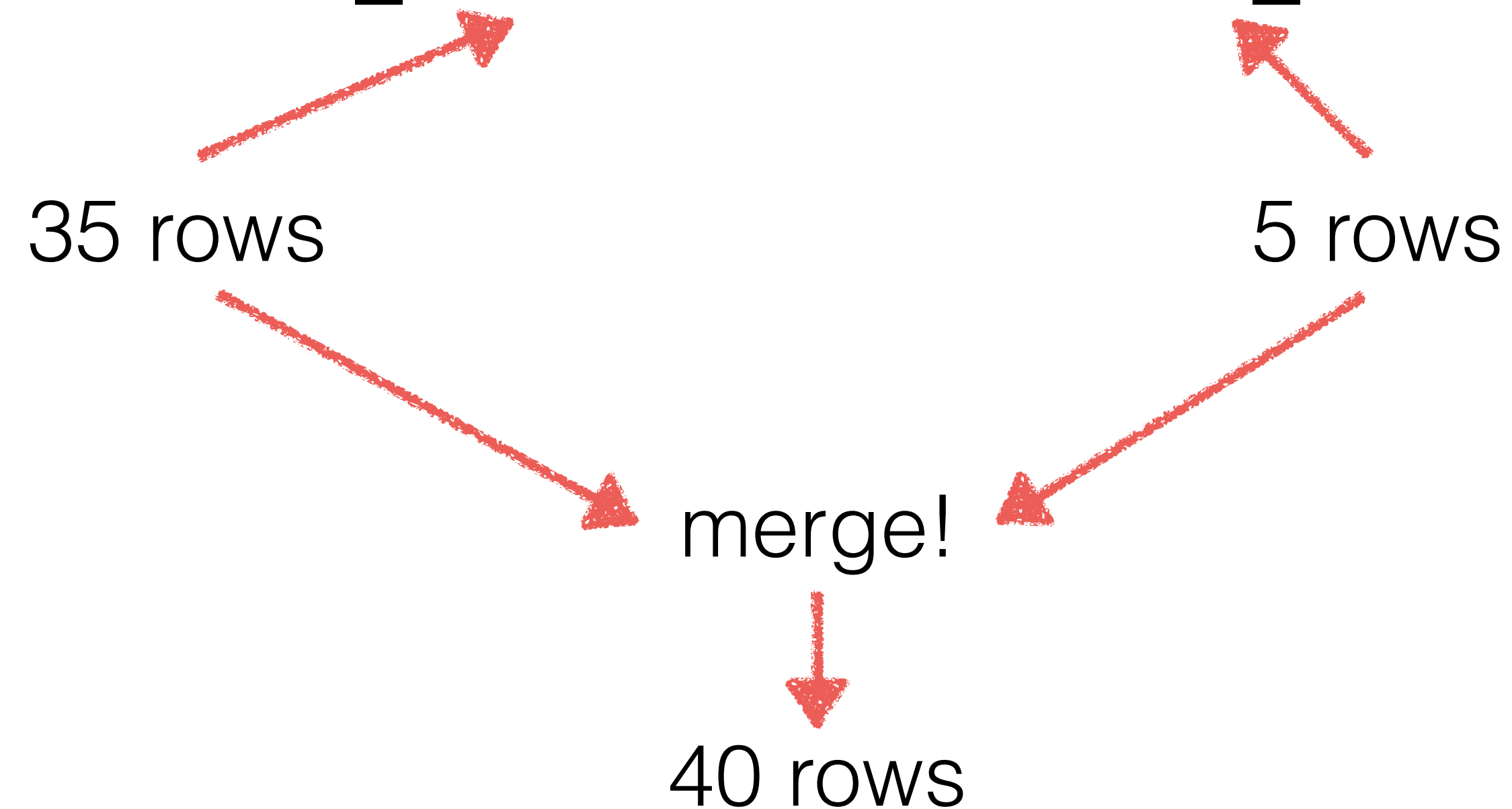


5 rows

```
SELECT film_id, actor_id  
FROM film_actor  
WHERE actor_id = 13 OR film_id = 13;
```



```
SELECT film_id, actor_id  
FROM film_actor  
WHERE actor_id = 13 OR film_id = 13;
```



"type"

ALL

index

range

index_subquery

unique_subquery

→ index_merge

ref_or_null

fulltext

ref

eq_ref

const

system

"type"

ALL

index

range

index_subquery

unique_subquery

index_merge

ref_or_null



fulltext

ref

eq_ref

const

system

"type"

ALL

index

range

index_subquery

unique_subquery

index_merge

ref_or_null

fulltext

ref

eq_ref

const

→ system

"type"

ALL

index

range

index_subquery

unique_subquery

index_merge

→ ref_or_null

fulltext

→ ref

→ eq_ref

→ const

system

"const"

```
SELECT * FROM film  
WHERE film_id = 123;
```

"const"

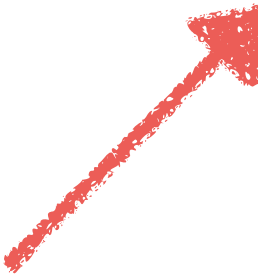
```
SELECT * FROM film  
WHERE film_id = 123;
```


constant

"const"

```
SELECT * FROM film
WHERE film_id = 123;
```

PRIMARY KEY,
so **one** possible value



constant



"ref"

```
SELECT * FROM film  
WHERE rating = 'PG-13';
```

"ref"

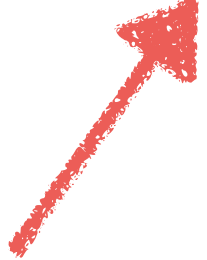
```
SELECT * FROM film  
WHERE rating = 'PG-13';
```



still a **constant**, but may
match more than one row

"ref"

```
SELECT * FROM film  
WHERE rating = 'PG-13';
```



KEY, but not
necessarily unique



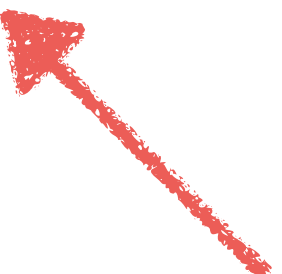
still a **constant**, but may
match more than one row

"ref_or_null"

```
SELECT * FROM film  
WHERE rating = 'PG-13'  
OR rating IS NULL;
```


"ref_or_null"

```
SELECT * FROM film  
WHERE rating = 'PG-13'  
OR rating IS NULL;
```



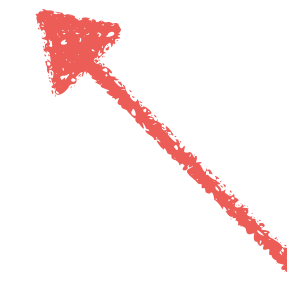
one pass to
find 'PG-13'

"ref_or_null"

```
SELECT * FROM film  
WHERE rating = 'PG-13'  
OR rating IS NULL;
```



extra pass to find null values



one pass to
find 'PG-13'

"eq_ref"


```
SELECT film_id FROM film_actor  
INNER JOIN film USING(film_id)  
WHERE actor_id = 123;
```

"eq_ref"

```
SELECT film_id FROM film_actor  
INNER JOIN film USING(film_id)  
WHERE actor_id = 123;
```

		✓		✓		✓	
type	possible_keys	key	key_len	ref			
ref	idx_rating	idx_rating	2	const			
rows	Extra						
223	Using index condition; Using filesort						

✓	✓	✓	✓	
type	possible_keys	key	key_len	ref
ref	idx_rating	idx_rating	2	const
↑				
rows	Extra			
223	Using index condition; Using filesort			



✓	✓	✓	✓	
type	possible_keys	key	key_len	ref
ref	idx_rating	idx_rating	2	const




rows	Extra
223	Using index condition; Using filesort

```
SELECT film_id FROM film_actor
INNER JOIN film USING(film_id)
WHERE actor_id = 123;
```

table	type	key	ref	rows
film_actor	ref	PRIMARY	const	32
film	eq_ref	PRIMARY	sakila.film_actor.film_id	1

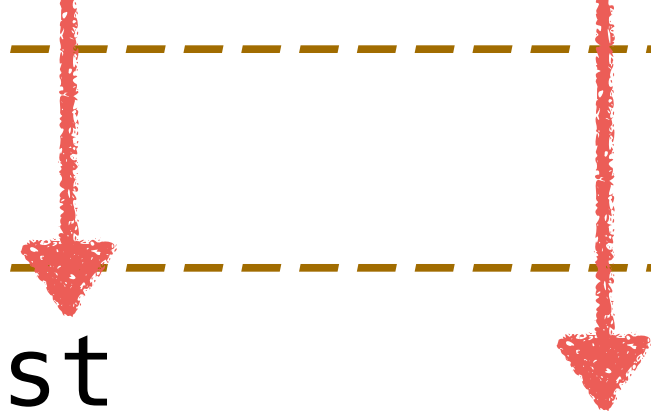

```
SELECT film_id FROM film_actor
INNER JOIN film USING(film_id)
WHERE actor_id = 123;
```


table	type	key	ref	rows
film_actor	ref	PRIMARY	const	32
film	eq_ref	PRIMARY	sakila.film_actor.film_id	1



```
SELECT film_id FROM film_actor
INNER JOIN film USING(film_id)
WHERE actor_id = 123;
```

table	type	key	ref	rows
film_actor	ref	PRIMARY	const	32
film	eq_ref	PRIMARY	sakila.film_actor.film_id	1






✓	✓	✓	✓	
type	possible_keys	key	key_len	ref
ref	idx_rating	idx_rating	2	const




rows	Extra
223	Using index condition; Using filesort



type	possible_keys	key	key_len	ref
ref	idx_rating	idx_rating	2	const



rows	Extra
223	Using index condition; Using filesort




type	possible_keys	key	key_len	ref
ref	idx_rating	idx_rating	2	const

rows	Extra
223	Using index condition; Using filesort



```
SELECT COUNT(*) FROM film
WHERE rating = 'PG-13'
ORDER BY title;
```






+	-	-	-	-	-	-	+
		COUNT	(*)		
+	-	-	-	-	-	-	+
				223			
+	-	-	-	-	-	-	+




✓					
type	possible_keys	key	key_len	ref	
ref	idx_rating	idx_rating	2	const	

rows	Extra	
223	Using index condition; Using filesort	














type	possible_keys	key	key_len	ref
ref	idx_rating	idx_rating	2	const




rows	Extra
223	Using index condition; Using filesort














type	possible_keys	key	key_len	ref
ref	idx_rating	idx_rating	2	const




rows	Extra
223	<u>Using index condition; Using filesort</u>



type	possible_keys	key	key_len	ref
ref	idx_rating	idx_rating	2	const



rows	Extra
223	<u>Using index condition; Using filesort</u>



rating	film_id
G	581
G	764
G	891
PG	137
PG	139
PG	308
PG-13	435
PG-13	565
PG-13	940
R	138
R	162
R	566
NC-17	147
NC-17	198
NC-17	933

rating	film_id
G	581
G	764
G	891
PG	137
PG	139
PG	308
PG-13	435
PG-13	565
PG-13	940
R	138
R	162
R	566
NC-17	147
NC-17	198
NC-17	933

film_id	title	rating	<omitted for brevity>
435	HOTEL HAPPINESS	PG- 13	etc...
565	MATRIX SNOWMAN	PG- 13	etc...
940	VICTORY ACADEMY	PG- 13	etc...

film_id	title	rating	<omitted for brevity>
435	MATRIX SNOWMAN	PG- 13	etc...
565	HOTEL HAPPINESS	PG- 13	etc...
940	VICTORY ACADEMY	PG- 13	etc...

film_id	title	rating	<omitted for brevity>
435	VICTORY ACADEMY	PG- 13	etc...
565	MATRIX SNOWMAN	PG- 13	etc...
940	HOTEL HAPPINESS	PG- 13	etc...

film_id	title	rating	<omitted for brevity>
435	MATRIX SNOWMAN	PG- 13	etc...
565	VICTORY ACADEMY	PG- 13	etc...
940	HOTEL HAPPINESS	PG- 13	etc...

film_id	title	rating	<omitted for brevity>
435	MATRIX SNOWMAN	PG- 13	etc...
565	VICTORY ACADEMY	PG- 13	etc...
940	HOTEL HAPPINESS	PG- 13	etc...

SHOW INDEX FROM film **WHERE** Column_name = 'title';

Table	Non_unique	Key_name	Seq_in_index	Column_name	<omitted for brevity>
film	1	idx_title	1	title	etc...

```
CREATE INDEX idx_rating_title  
ON film(rating, title);
```

```
CREATE INDEX idx_rating_title  
ON film(rating, title);
```



```
CREATE INDEX idx_rating_title  
ON film(rating, title);
```








idx_rating_title

rating	title	film_id
PG-13	HOTEL HAPPINESS	435
PG-13	MATRIX SNOWMAN	565
PG-13	VICTORY ACADEMY	940


idx_rating_title

rating	title	film_id
PG-13	HOTEL HAPPINESS	435
PG-13	MATRIX SNOWMAN	565
PG-13	VICTORY ACADEMY	940

order is guaranteed!

type	possible_keys	key	key_len	ref
ref	idx_rating, idx_rating_title	idx_rating_title	2	const








rows	Extra
223	Using index condition

✓		✓		✓		✓		✓
type	possible_keys	key	key_len	ref				
ref	idx_rating, idx_rating_title	idx_rating_title	2	const				


✓								
rows	Extra							
223	Using index	condition						

✓		✓		✓		✓		✓
type	possible_keys	key	key_len	ref				
ref	idx_rating, idx_rating_title	idx_rating_title	2	const				

✓								
rows	Extra							
223	Using index	condition						

type	possible_keys	key	key_len	ref
ref	idx_rating, idx_rating_title	idx_rating_title	2	const



rows	Extra
223	Using index condition

✓		✓		✓		✓		✓
type	possible_keys	key	key_len	ref				
ref	idx_rating, idx_rating_title	idx_rating_title	2	const				

✓								
rows	Extra							
223	<u>Using index</u>	condition						

These films are rated PG-13!

HOTEL HAPPINESS

MATRIX SNOWMAN

VICTORY ACADEMY

These films are rated PG-13!

HOTEL HAPPINESS

MATRIX SNOWMAN

VICTORY ACADEMY



film_id, title






```
SELECT * FROM film
WHERE rating = 'PG-13'
ORDER BY title;
```

```
SELECT * FROM film  
WHERE rating = 'PG-13'  
ORDER BY title;
```




```
SELECT film_id, title  
FROM film  
WHERE rating = 'PG-13'  
ORDER BY title;
```

```
SELECT film_id, title  
FROM film  
WHERE rating = 'PG-13'  
ORDER BY title;
```

type	possible_keys	key	key_len	ref
ref	idx_rating, idx_rating_title	idx_rating_title	2	const



rows	Extra
223	Using where; Using index

✓		✓		✓		✓		✓
type	possible_keys	key	key_len	ref				
ref	idx_rating, idx_rating_title	idx_rating_title	2	const				

✓								
rows	Extra							
223	Using where;	Using index						

✓	✓	✓	✓	✓
type	possible_keys	key	key_len	ref
ref	idx_rating, idx_rating_title	idx_rating_title	2	const

✓	✓
rows	Extra
223	Using where; <u>Using index</u>

✓	✓	✓	✓	✓
type	possible_keys	key	key_len	ref
ref	idx_rating, idx_rating_title	idx_rating_title	2	const

✓	✓
rows	Extra
223	Using where; Using index

SHOW TABLE STATUS
WHERE Name = 'film' \G

Name: film
Engine: InnoDB
Version: 10
Row_format: **Dynamic**
Rows: 1000
Avg_row_length: **196**
Data_length: **196608**
Max_data_length: **0**
Index_length: **81920**
Data_free: **0**
Auto_increment: **1001**
Create_time: **2017-01-28 13:06:42**
Update_time: **2017-01-28 12:35:48**
Check_time: **NULL**
Collation: utf8_general_ci
Checksum: **NULL**
Create_options:
Comment:

Name: film
Engine: InnoDB
Version: 10
Row_format: **Dynamic**
Rows: 1000
Avg_row_length: **196**
Data_length: 196608
Max_data_length: **0**
Index_length: 81920
Data_free: **0**
Auto_increment: **1001**
Create_time: **2017-01-28 13:06:42**
Update_time: **2017-01-28 12:35:48**
Check_time: **NULL**
Collation: utf8_general_ci
Checksum: **NULL**
Create_options:
Comment:

Data_length: **196608**


Index_length: **81920**

ANALYZE TABLE film;

Table	Op	Msg_type	Msg_text
sakila.film	analyze	status	OK

Data_length: **196608**

Index_length: **147456**


$$\begin{array}{r} 147456 \\ - 81920 \\ \hline 65536 \end{array}$$

(with `idx_rating + idx_rating_title`)
(original index length)

**INDEXES ARE
NOT "FREE" !**

DROP INDEX idx_rating
ON film;

ANALYZE TABLE film;

SHOW TABLE STATUS
WHERE Name = 'film' \G

Data_length: **196608**

Index_length: **131072**

$$\begin{array}{r} 147456 \\ - 131072 \\ \hline 16384 \end{array}$$

(with `idx_rating + idx_rating_title`)
(after removing `idx_rating`)

$$\frac{16384}{196608} \sim 8.3\%$$

$$\begin{array}{r} 1 \text{ TB} \\ \times 8.3\% \\ \hline \sim 80 \text{ GB} \end{array}$$

rating	film_id
G	581
G	764
G	891
PG	137
PG	139
PG	308
PG-13	435
PG-13	565
PG-13	940
R	138
R	162
R	566
NC-17	147
NC-17	198
NC-17	933

rating	film_id
G	581
G	764
G	891
PG	137
PG	139
PG	308
PG-13	435
PG-13	565
PG-13	940
R	138
R	162
R	566
NC-17	147
NC-17	198
NC-17	933

rating	title	film_id
G	MINORITY KISS	581
G	SATURDAY LAMBS	764
G	TIMBERLAND SKY	891
PG	CHARADE DUFFEL	137
PG	CHASING FIGHT	139
PG	FERRIS MOTHER	308
PG-13	HOTEL HAPPINESS	435
PG-13	MATRIX SNOWMAN	565
PG-13	VICTORY ACADEMY	940
R	CHARIOTS CONSPIRACY	138
R	CLUELESS BUCKET	162
R	MAUDE MOD	566
NC-17	CHOCOLAT HARRY	147
NC-17	CRYSTAL BREAKING	198
NC-17	VAMPIRE WHALE	933

rating	film_id
G	581
G	764
G	891
PG	137
PG	139
PG	308
PG-13	435
PG-13	565
PG-13	940
R	138
R	162
R	566
NC-17	147
NC-17	198
NC-17	933

rating	title	film_id
G	MINORITY KISS	581
G	SATURDAY LAMBS	764
G	TIMBERLAND SKY	891
PG	CHARADE DUFFEL	137
PG	CHASING FIGHT	139
PG	FERRIS MOTHER	308
PG-13	HOTEL HAPPINESS	435
PG-13	MATRIX SNOWMAN	565
PG-13	VICTORY ACADEMY	940
R	CHARIOTS CONSPIRACY	138
R	CLUELESS BUCKET	162
R	MAUDE MOD	566
NC-17	CHOCOLAT HARRY	147
NC-17	CRYSTAL BREAKING	198
NC-17	VAMPIRE WHALE	933

rating	film_id
G	581
G	764
G	891
PG	137
PG	139
PG	308
PG-13	435
PG-13	565
PG-13	940
R	138
R	162
R	566
NC-17	147
NC-17	198
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rating	title	film_id
G	MINORITY KISS	581
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R	CHARIOTS CONSPIRACY	138
R	CLUELESS BUCKET	162
R	MAUDE MOD	566
NC-17	CHOCOLAT HARRY	147
NC-17	CRYSTAL BREAKING	198
NC-17	VAMPIRE WHALE	933

id	select_type	table	partitions	type	possible_keys	key
1	SIMPLE	film	NULL	ref	idx_rating_title	idx_rating_title

key_len	ref	rows	filtered	Extra
2	const	223	100.00	Using where; Using index

id	select_type	table	partitions	type	possible_keys	key
1	SIMPLE	film	NULL	ref	idx_rating_title	idx_rating_title

key_len	ref	rows	filtered	Extra
2	const	223	100.00	Using where; Using index

```
SELECT rating, film_id
FROM film AS outer_film
WHERE rating = 'PG-13' AND film_id NOT IN (
    SELECT film_id FROM film AS inner_film
    INNER JOIN inventory USING (film_id)
    INNER JOIN rental USING (inventory_id)
);
```

```
SELECT rating, film_id
FROM film AS outer_film
WHERE rating = 'PG-13' AND film_id NOT IN (
→ SELECT film_id FROM film AS inner_film
    INNER JOIN inventory USING (film_id)
    INNER JOIN rental USING (inventory_id)
);
```

```
SELECT rating, film_id
FROM film AS outer_film
WHERE rating = 'PG-13' AND film_id NOT IN (
→ SELECT film_id FROM film AS inner_film
  INNER JOIN inventory USING (film_id)
  INNER JOIN rental USING (inventory_id)
);
```

rating	film_id
PG-13	33
PG-13	36
PG-13	108
PG-13	325
PG-13	642
PG-13	701
PG-13	712
PG-13	801
PG-13	909
PG-13	943

id	select_type	table	partitions	type	possible_keys
1	PRIMARY	film	NULL	ref	idx_rating_title
2	DEPENDENT SUBQUERY	film	NULL	eq_ref	PRIMARY
2	DEPENDENT SUBQUERY	inventory	NULL	ref	PRIMARY, idx_fk_film_id
2	DEPENDENT SUBQUERY	rental	NULL	ref	idx_fk_inventory_id

key	key_len	ref	rows	filtered	Extra
idx_rating_title	2	const	223	100.00	Using where; Using index
PRIMARY	2	func	1	100.00	Using index
idx_fk_film_id	2	func	4	100.00	Using where; Using index
idx_fk_inventory_id	3	sakila.inventory.inventory_id	1	100.00	Using index

id	select_type	table	partitions	type	possible_keys
1	PRIMARY	film	NULL	ref	idx_rating_title
2	DEPENDENT SUBQUERY	film	NULL	eq_ref	PRIMARY
2	DEPENDENT SUBQUERY	inventory	NULL	ref	PRIMARY, idx_fk_film_id
2	DEPENDENT SUBQUERY	rental	NULL	ref	idx_fk_inventory_id

key	key_len	ref	rows	filtered	Extra
idx_rating_title	2	const	223	100.00	Using where; Using index
PRIMARY	2	func	1	100.00	Using index
idx_fk_film_id	2	func	4	100.00	Using where; Using index
idx_fk_inventory_id	3	sakila.inventory.inventory_id	1	100.00	Using index

```
SELECT rating, film_id
FROM film AS outer_film
WHERE rating = 'PG-13' AND film_id NOT IN (
    SELECT film_id FROM film AS inner_film
    INNER JOIN inventory USING (film_id)
    INNER JOIN rental USING (inventory_id)
);
```

```
SELECT rating, film_id
FROM film AS outer_film
WHERE rating = 'PG-13' AND film_id NOT IN (
    SELECT film_id FROM film AS inner_film
    INNER JOIN inventory USING (film_id)
    INNER JOIN rental USING (inventory_id)
);
```

```
SELECT rating, film_id
FROM film AS outer_film
WHERE rating = 'PG-13' AND film_id NOT IN (
    SELECT film_id FROM film AS inner_film
    INNER JOIN inventory USING (film_id)
    INNER JOIN rental USING (inventory_id)
    16044 rows in set (0.02 sec)
);
```

```
EXPLAIN SELECT rating, film_id
FROM film AS outer_film
WHERE rating = 'PG-13' AND film_id NOT IN (
    SELECT film_id FROM film AS inner_film
    INNER JOIN inventory USING (film_id)
    INNER JOIN rental USING (inventory_id)
);
```

```
EXPLAIN SELECT rating, film_id
FROM film AS outer_film
WHERE rating = 'PG-13' AND film_id NOT IN (
    SELECT film_id FROM film AS inner_film
    INNER JOIN inventory USING (film_id)
    INNER JOIN rental USING (inventory_id)
);
4 rows in set, 1 warning (0.01 sec)
```

```
EXPLAIN SELECT rating, film_id
FROM film AS outer_film
WHERE rating = 'PG-13' AND film_id NOT IN (
    SELECT film_id FROM film AS inner_film
    INNER JOIN inventory USING (film_id)
    INNER JOIN rental USING (inventory_id)
);
4 rows in set, 1 warning (0.01 sec)
```

SHOW WARNINGS \G

***** 1. row *****

Level: Note

Code: 1003

```
Message: /* select#1 */ select `sakila`.`outer_film`.`rating`
AS `rating`,`sakila`.`outer_film`.`film_id` AS `film_id` from
`sakila`.`film` `outer_film` where
((`sakila`.`outer_film`.`rating` = 'PG-13') and
(not(<in_optimizer>(`sakila`.`outer_film`.`film_id`,<exists>(
/* select#2 */ select 1 from `sakila`.`film` `inner_film` join
`sakila`.`inventory` join `sakila`.`rental` where
((`sakila`.`inventory`.`film_id` =
`sakila`.`inner_film`.`film_id`) and
(`sakila`.`rental`.`inventory_id` =
`sakila`.`inventory`.`inventory_id`) and
(<cache>(`sakila`.`outer_film`.`film_id`) =
`sakila`.`inner_film`.`film_id`)))))))
1 row in set (0.00 sec)
```

***** 1. row *****

Level: Note

Code: 1003

```
Message: /* select#1 */ select `sakila`.`outer_film`.`rating`
AS `rating`,`sakila`.`outer_film`.`film_id` AS `film_id` from
`sakila`.`film` `outer_film` where
((`sakila`.`outer_film`.`rating` = 'PG-13') and
(not(<in_optimizer>(`sakila`.`outer_film`.`film_id`,<exists>(
/* select#2 */ select 1 from `sakila`.`film` `inner_film` join
`sakila`.`inventory` join `sakila`.`rental` where
((`sakila`.`inventory`.`film_id` =
`sakila`.`inner_film`.`film_id`) and
(`sakila`.`rental`.`inventory_id` =
`sakila`.`inventory`.`inventory_id`) and
(<cache>(`sakila`.`outer_film`.`film_id`) =
`sakila`.`inner_film`.`film_id`)))))))
1 row in set (0.00 sec)
```

***** 1. row *****

Level: Note

Code: 1003

Message: /* select#1 */ select `sakila`.`outer_film`.`rating`
AS `rating`, sakila.`outer_film`.`film_id` AS `film_id` from
`sakila`.`film` `outer_film` where
((`sakila`.`outer_film`.`rating` = 'PG-13') and
(not(<in_optimizer>(`sakila`.`outer_film`.`film_id`,<exists>(
/* select#2 */ select 1 from `sakila`.`film` `inner_film` join
`sakila`.`inventory` join `sakila`.`rental` where
((`sakila`.`inventory`.`film_id` =
`sakila`.`inner_film`.`film_id`) and
(`sakila`.`rental`.`inventory_id` =
`sakila`.`inventory`.`inventory_id`) and
(<cache>(`sakila`.`outer_film`.`film_id`) =
`sakila`.`inner_film`.`film_id`))))))
1 row in set (0.00 sec)

***** 1. row *****

Level: Note

Code: 1003

```
Message: /* select#1 */ select `sakila`.`outer_film`.`rating`
AS `rating`, sakila.`outer_film`.`film_id` AS `film_id` from
`sakila`.`film` `outer_film` where
((`sakila`.`outer_film`.`rating` = 'PG-13') and
(not(<in_optimizer>(`sakila`.`outer_film`.`film_id`,<exists>(
/* select#2 */ select 1 from `sakila`.`film` `inner_film` join
`sakila`.`inventory` join `sakila`.`rental` where
((`sakila`.`inventory`.`film_id` =
`sakila`.`inner_film`.`film_id`) and
(`sakila`.`rental`.`inventory_id` =
`sakila`.`inventory`.`inventory_id`) and
(<cache>(`sakila`.`outer_film`.`film_id`) =
`sakila`.`inner_film`.`film_id`)))))))
1 row in set (0.00 sec)
```

```
SELECT rating, film_id
FROM film AS outer_film
WHERE rating = 'PG-13' AND
      NOT EXISTS (
        SELECT 1 FROM film
        JOIN inventory
        JOIN rental
        WHERE inventory.film_id = film.film_id
              AND rental.inventory_id = inventory.inventory_id
              AND outer_film.film_id = film.film_id
      )
```

```
SELECT rating, film_id
FROM film AS outer_film
WHERE rating = 'PG-13' AND
      NOT EXISTS (
        SELECT 1 FROM film
        JOIN inventory
        JOIN rental
        WHERE inventory.film_id = film.film_id
              AND rental.inventory_id = inventory.inventory_id
              AND outer_film.film_id = film.film_id
      )
```



```
SELECT rating, film_id
FROM film AS outer_film
WHERE rating = 'PG-13' AND
      NOT EXISTS (
        SELECT 1 FROM film
        JOIN inventory
        JOIN rental
        WHERE inventory.film_id = film.film_id
              AND rental.inventory_id = inventory.inventory_id
              AND outer_film.film_id = film.film_id
      )
ERROR 1054 (42S22): Unknown column 'outer_film.film_id'
in 'where clause'
```

```
SELECT rating, film_id
FROM film AS outer_film
WHERE rating = 'PG-13' AND
      NOT EXISTS (
        SELECT 1 FROM film
        JOIN inventory
        JOIN rental
        WHERE inventory.film_id = film.film_id
              AND rental.inventory_id = inventory.inventory_id
              AND outer_film.film_id = film.film_id
      )
ERROR 1054 (42S22): Unknown column 'outer_film.film_id'
in 'where clause'
```


"for each of these..."

```
SELECT rating, film_id
FROM film AS outer_film
WHERE rating = 'PG-13' AND
      NOT EXISTS (
        SELECT 1 FROM film
        JOIN inventory
        JOIN rental
        WHERE inventory.film_id = film.film_id
              AND rental.inventory_id = inventory.inventory_id
              AND outer_film.film_id = film.film_id
      )
```

"... do this!"

```
SELECT rating, film.film_id FROM film
LEFT JOIN (
    SELECT film_id FROM inventory
    INNER JOIN rental USING (inventory_id)
) rented_films ON film.film_id = rented_films.film_id
WHERE rented_films.film_id IS NULL
AND rating = 'PG-13';
```

rating	film_id
PG-13	33
PG-13	36
PG-13	108
PG-13	325
PG-13	642
PG-13	701
PG-13	712
PG-13	801
PG-13	909
PG-13	943

id	select_type	table	partitions	type	possible_keys	key
1	SIMPLE	film	NULL	ref	idx_rating_title	idx_rating_title
1	SIMPLE	inventory	NULL	ref	PRIMARY,idx_fk_film_id	idx_fk_film_id
1	SIMPLE	rental	NULL	ref	idx_fk_inventory_id	idx_fk_inventory_id

key_len	ref	rows	filtered	Extra
2	const	223	100.00	Using index
2	sakila.film.film_id	4	100.00	Using where; Using index
3	sakila.inventory.inventory_id	3	100.00	Using index

id	select_type	table	partitions	type	possible_keys	key
1	SIMPLE	film	NULL	ref	idx_rating_title	idx_rating_title
1	SIMPLE	inventory	NULL	ref	PRIMARY ,idx_fk_film_id	idx_fk_film_id
1	SIMPLE	rental	NULL	ref	idx_fk_inventory_id	idx_fk_inventory_id

key_len	ref	rows	filtered	Extra
2	const	223	100.00	Using index
2	sakila.film.film_id	4	100.00	Using where; Using index
3	sakila.inventory.inventory_id	3	100.00	Using index

Tables_in_performance_schema		
accounts	events_waits_history	replication_connection_configuration
cond_instances	events_waits_history_long	replication_connection_status
events_stages_current	events_waits_summary_by_account_by_event_name	replication_group_member_stats
events_stages_history	events_waits_summary_by_host_by_event_name	replication_group_members
events_stages_history_long	events_waits_summary_by_instance	rwlock_instances
events_stages_summary_by_account_by_event_name	events_waits_summary_by_thread_by_event_name	session_account_connect_attrs
events_stages_summary_by_host_by_event_name	events_waits_summary_by_user_by_event_name	session_connect_attrs
events_stages_summary_by_thread_by_event_name	events_waits_summary_global_by_event_name	session_status
events_stages_summary_by_user_by_event_name	file_instances	session_variables
events_stages_summary_global_by_event_name	file_summary_by_event_name	setup_actors
events_statements_current	file_summary_by_instance	setup_consumers
events_statements_history	global_status	setup_instruments
events_statements_history_long	global_variables	setup_objects
events_statements_summary_by_account_by_event_name	host_cache	setup_timers
events_statements_summary_by_digest	hosts	socket_instances
events_statements_summary_by_host_by_event_name	memory_summary_by_account_by_event_name	socket_summary_by_event_name
events_statements_summary_by_program	memory_summary_by_host_by_event_name	socket_summary_by_instance
events_statements_summary_by_thread_by_event_name	memory_summary_by_thread_by_event_name	status_by_account
events_statements_summary_by_user_by_event_name	memory_summary_by_user_by_event_name	status_by_host
events_statements_summary_global_by_event_name	memory_summary_global_by_event_name	status_by_thread
events_transactions_current	metadata_locks	status_by_user
events_transactions_history	mutex_instances	table_handles
events_transactions_history_long	objects_summary_global_by_type	table_io_waits_summary_by_index_usage
events_transactions_summary_by_account_by_event_name	performance_timers	table_io_waits_summary_by_table
events_transactions_summary_by_host_by_event_name	prepared_statements_instances	table_lock_waits_summary_by_table
events_transactions_summary_by_thread_by_event_name	replication_applier_configuration	threads
events_transactions_summary_by_user_by_event_name	replication_applier_status	user_variables_by_thread
events_transactions_summary_global_by_event_name	replication_applier_status_by_coordinator	users
events_waits_current	replication_applier_status_by_worker	variables_by_thread

<https://dev.mysql.com/doc/refman/5.7/en/performance-schema.html>

"The Short Version"

1. Turn it on
2. Run the query
3. Get the `event_id`
4. Look at stuff!

<https://dev.mysql.com/doc/refman/5.7/en/performance-schema-query-profiling.html>

```
SELECT rating, film.film_id FROM film
LEFT JOIN (
    SELECT film_id FROM inventory
    INNER JOIN rental USING (inventory_id)
) rented_films ON film.film_id = rented_films.film_id
WHERE rented_films.film_id IS NULL
AND rating = 'PG-13';
```


Stage	Duration
stage/ sql /starting	0.000116
stage/ sql /checking permissions	0.000004
stage/ sql /checking permissions	0.000002
stage/ sql /checking permissions	0.000006
stage/ sql /Opening tables	0.000049
stage/ sql /init	0.000066
stage/ sql /System lock	0.000011
stage/ sql /optimizing	0.000018
stage/ sql /statistics	0.000117
stage/ sql /preparing	0.000023
stage/ sql /executing	0.000002
stage/ sql /Sending data	0.001784
stage/ sql /end	0.000003
stage/ sql /query end	0.000008
stage/ sql /closing tables	0.000010
stage/ sql /freeing items	0.000026
stage/ sql /cleaning up	NULL

17 rows in set (0.00 sec)

```
SELECT rating, film_id
FROM film AS outer_film
WHERE rating = 'PG-13' AND film_id NOT IN (
    SELECT film_id FROM film AS inner_film
    INNER JOIN inventory USING (film_id)
    INNER JOIN rental USING (inventory_id)
);
```

Stage	Duration
stage/ sql /starting	0.000112
stage/ sql /checking permissions	0.000011
stage/ sql /checking permissions	0.000002
stage/ sql /checking permissions	0.000002
stage/ sql /checking permissions	0.000005
stage/ sql /Opening tables	0.000029
stage/ sql /init	0.000070
stage/ sql / System lock	0.000011
stage/ sql /optimizing	0.000013
stage/ sql / statistics	0.000077
stage/ sql /preparing	0.000017
stage/ sql /optimizing	0.000011
stage/ sql / statistics	0.000052
stage/ sql /preparing	0.000012
stage/ sql /executing	0.000003
stage/ sql /Sending data	0.000031
stage/ sql /executing	0.000002
stage/ sql /Sending data	0.000038
stage/ sql /executing	0.000002

stage/sql/Sending data	0.0000014
stage/sql/executing	0.0000001
stage/sql/Sending data	0.0000016
stage/sql/executing	0.0000002
stage/sql/Sending data	0.0000014
stage/sql/executing	0.0000002
stage/sql/Sending data	0.0000013
stage/sql/executing	0.0000002
stage/sql/Sending data	0.0000014
stage/sql/executing	0.0000002
stage/sql/Sending data	0.0000014
stage/sql/executing	0.0000002
stage/sql/Sending data	0.0000014
stage/sql/executing	0.0000001
stage/sql/Sending data	0.0000014
stage/sql/executing	0.0000002
stage/sql/Sending data	0.0000018
stage/sql/end	0.0000003
stage/sql/query end	0.0000007
stage/sql/closing tables	0.0000008
stage/sql/freeing items	0.0000021
stage/sql/cleaning up	0.0000001

467 rows in set (0.00 sec)

stage/sql/Sending data	0.0000014
stage/sql/executing	0.0000001
stage/sql/Sending data	0.0000016
stage/sql/executing	0.0000002
stage/sql/Sending data	0.0000014
stage/sql/executing	0.0000002
stage/sql/Sending data	0.0000013
stage/sql/executing	0.0000002
stage/sql/Sending data	0.0000014
stage/sql/executing	0.0000002
stage/sql/Sending data	0.0000014
stage/sql/executing	0.0000002
stage/sql/Sending data	0.0000014
stage/sql/executing	0.0000001
stage/sql/Sending data	0.0000014
stage/sql/executing	0.0000002
stage/sql/Sending data	0.0000018
stage/sql/end	0.0000003
stage/sql/query end	0.0000007
stage/sql/closing tables	0.0000008
stage/sql/freeing items	0.0000021
stage/sql/cleaning up	0.0000001

!!!

→ 467 rows in set (0.00 sec)

"DEPENDENT SUBQUERY IS BAD!"

~~"DEPENDENT SUBQUERY IS BAD!"~~

~~"DEPENDENT SUBQUERY IS BAD!"~~

DEPENDENT SUBQUERY IS
SOMETHING TO INVESTIGATE

~~"DEPENDENT SUBQUERY IS BAD!"~~

DEPENDENT SUBQUERY IS
SOMETHING TO INVESTIGATE
AND SO ARE...

- DEPENDENT UNION
- UNCACHEABLE SUBQUERY
- UNCACHEABLE UNION

TAKEAWAYS

EXPLAIN

PROFILE

TEST

"CHEAT"

<https://joind.in/talk/f06be>

(in case you missed it...)



Questions?

Thanks!