

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

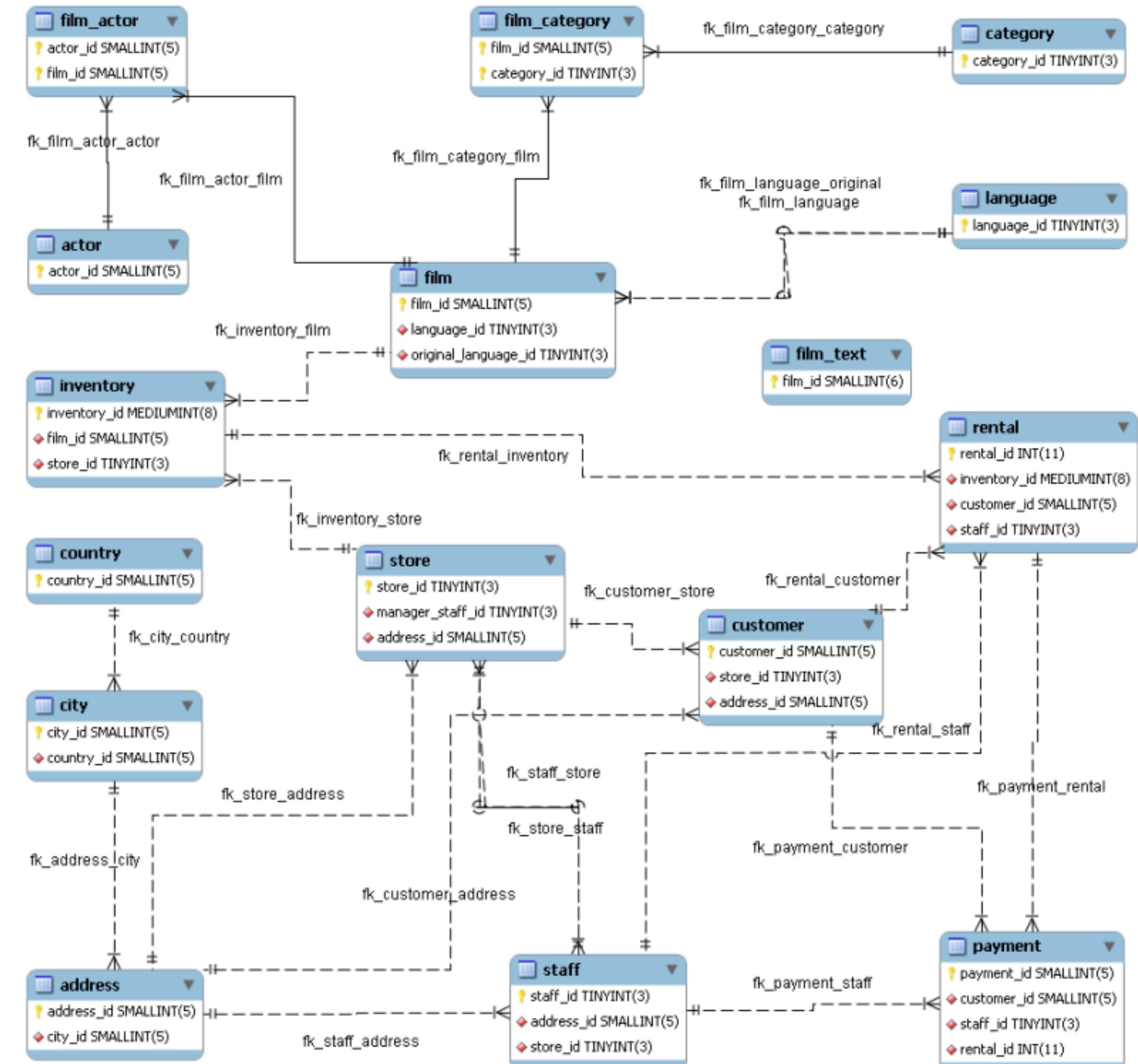
<https://dev.mysql.com/downloads/mysql/>

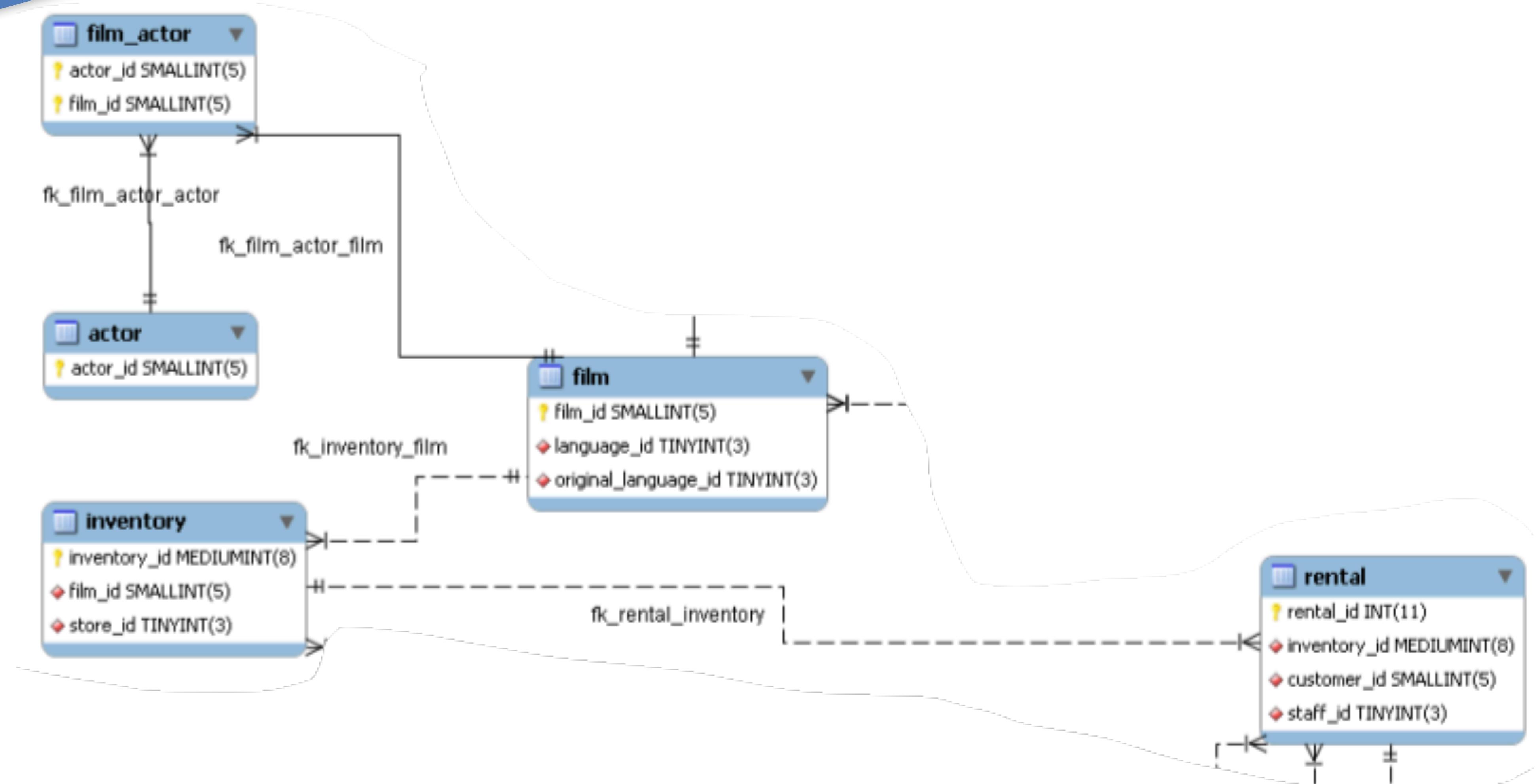
Sakila Sample Database

```
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;
```

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

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

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

```
SELECT * FROM film  
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Query Execution Plan

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```



film_id	title	length	rating	rental_rate	replacement_cost	stock_level	last_update
1	A Star Is Born	119	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
2	Die Hard	134	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
3	Die Hard With a Vengeance	134	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
4	Gladiator	154	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
5	The Godfather	169	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
6	The Godfather Part II	169	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
7	Inception	148	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
8	Interstellar	148	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
9	Star Wars: Episode V - The Empire Strikes Back	152	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
10	Star Wars: Episode VI - Return of the Jedi	152	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
11	The Shawshank Redemption	148	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
12	The Silence of the Lambs	121	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
13	The Seven Samurai	156	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
14	The Thin Red Line	154	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
15	The Wizard of Oz	142	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
16	Young Mr. Lincoln	132	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
17	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
18	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
19	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
20	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
21	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
22	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
23	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
24	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
25	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
26	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
27	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
28	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
29	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
30	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
31	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
32	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
33	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
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36	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
37	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
38	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
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40	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
41	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
42	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
43	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
44	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
45	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
46	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
47	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
48	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
49	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
50	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
51	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
52	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
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55	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
56	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
57	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
58	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
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63	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
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65	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
66	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
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68	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
69	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
70	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
71	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
72	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
73	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
74	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
75	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
76	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
77	Seven Brides for Seven Brothers	125	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
78	Seven Dwarfs	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
79	Seven Year Itch, The	102	PG-13	2.99	19.99	50	2006-02-14 12:45:39.0
80	Seven Brides for Seven Brothers	125	PG-13	2.99			

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

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

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

select_type
SIMPLE

	table	
	film	

	partitions	
	NULL	

	+ - - - - +
	type
	+ - - - - +
	ALL
	+ - - - - +

possible_keys
NULL

	+-----+
	key
	+-----+
	NULL
	+-----+

	key_len	
	NULL	

	+-----+
	ref
	+-----+
	NULL
	+-----+

rows
1000

filtered

+-----+
| Extra |
+-----+
| Using where; Using filesort |
+-----+

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

<code>id</code>	<code>select_type</code>	<code>table</code>	<code>partitions</code>	<code>type</code>	<code>possible_keys</code>	<code>key</code>	<code>key_len</code>	<code>ref</code>	<code>rows</code>	<code>filtered</code>	<code>Extra</code>
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

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

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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

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
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+-----+ <th> id name </th> <th>-----+</th>	id name	-----+
id name		-----+
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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
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13	Johns, Grady	3624 Id St.	Little Rock	AR	71837	(237) 999-9658
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17	Baxter, Nelle	924-9300 Fames Av.	Houston	TX	21327	(713) 684-9391
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17	Baxter, Nelle	924-9300 Fames Av.	Houston	TX	21327	(713) 684-9391
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20	Christensen, Mona	P.O. Box 948, 3731 Dui Avenue	Virginia Beach	VA	73884	(469) 792-9473

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

+-----+ <th>id</th> <th>select_type</th> <th>table</th> <th>partitions</th> <th>type</th> <th>possible_keys</th> <th>key</th> <th>key_len</th> <th>ref</th> <th>rows</th> <th>filtered</th> <th>Extra</th>	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	const
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			const
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	ref_or_null
index	fulltext
range	ref
index_subquery	eq_ref
unique_subquery	const
index_merge	system



ALL
index
range
index_subquery
unique_subquery
index_merge

"type"

ref_or_null
fulltext
ref
eq_ref
const
system

	"type"
ALL	ref_or_null
→ index	fulltext
range	ref
index_subquery	eq_ref
unique_subquery	const
index_merge	system

+-----+-----+		
id name		
+-----+-----+		
17	Baxter, Nelle	
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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
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"index"

SELECT name FROM person;

SELECT * FROM person;

SELECT name, phone FROM person;

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	17	Baxter, Nelle
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"index"

`SELECT name FROM person;`

`SELECT * FROM person;`

"ALL"

`SELECT name, phone FROM person;`

	"type"
ALL	ref_or_null
→ index	fulltext
range	ref
index_subquery	eq_ref
unique_subquery	const
index_merge	system

	"type"
ALL	ref_or_null
index	fulltext
→ range	ref
index_subquery	eq_ref
unique_subquery	const
index_merge	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
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```
SELECT * FROM person  
WHERE name BETWEEN 'M' AND 'Z';
```

+-----+-----+	id name	+-----+
17	Baxter, Nelle	
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9	Wilder, Nita	
6	Wolf, Kaden	

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



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

	"type"
ALL	ref_or_null
index	fulltext
→ range	ref
index_subquery	eq_ref
unique_subquery	const
index_merge	system

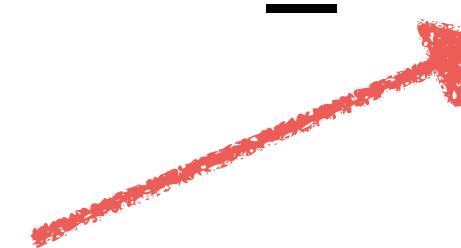
	"type"
ALL	ref_or_null
index	fulltext
range	ref
→ index_subquery	eq_ref
→ unique_subquery	const
index_merge	system

	"type"
ALL	ref_or_null
index	fulltext
range	ref
index_subquery	eq_ref
unique_subquery	const
→ index_merge	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

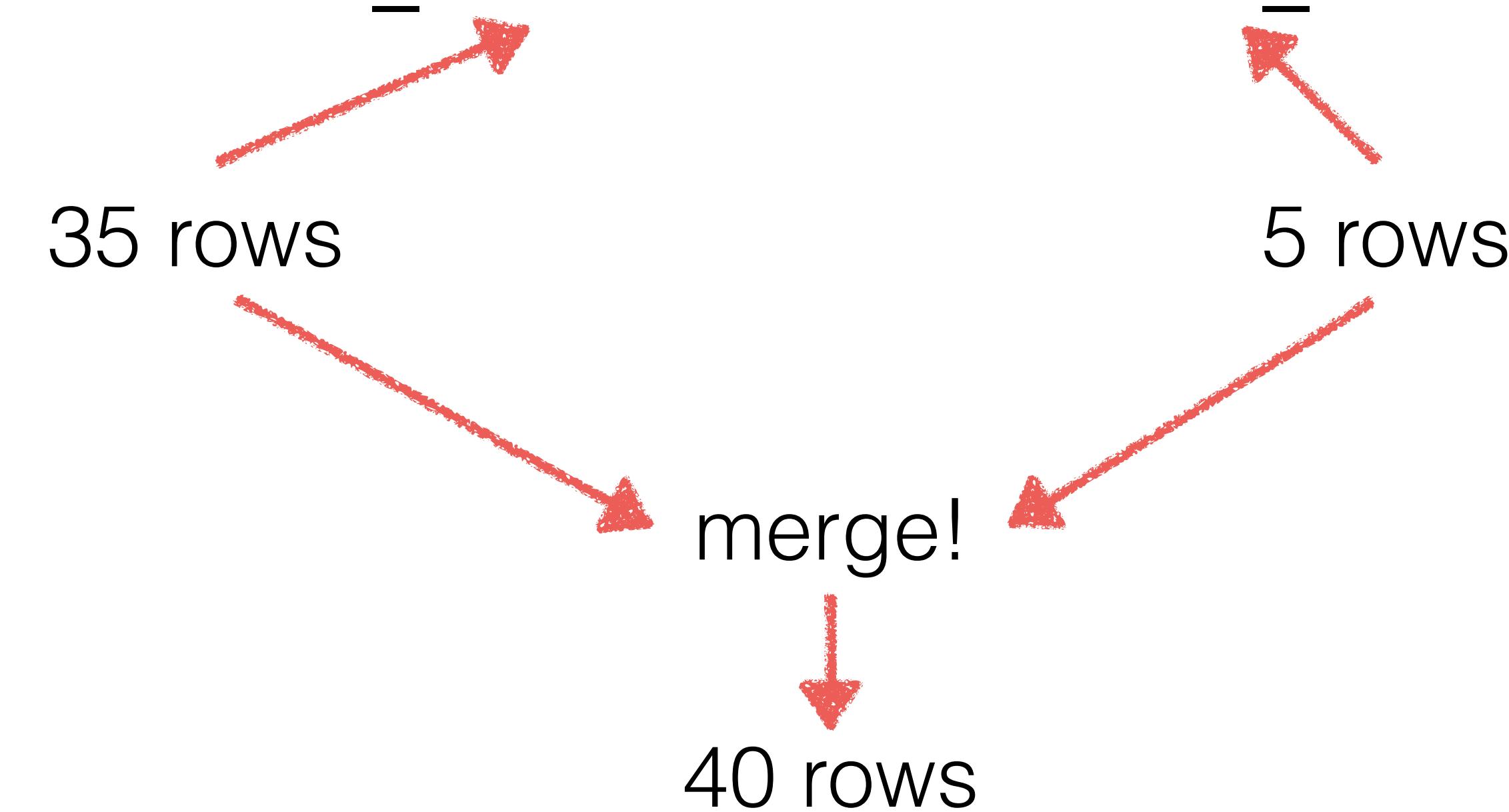
```
SELECT film_id, actor_id  
FROM film_actor  
WHERE actor_id = 13 OR film_id = 13;
```

35 rows

5 rows

merge!

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



	"type"
ALL	ref_or_null
index	fulltext
range	ref
index_subquery	eq_ref
unique_subquery	const
→ index_merge	system

ALL
index
range
index_subquery
unique_subquery
index_merge

"type"



ref_or_null
fulltext
ref
eq_ref
const
system

	"type"
ALL	ref_or_null
index	fulltext
range	ref
index_subquery	eq_ref
unique_subquery	const
index_merge	system

	"type"
ALL	→ ref_or_null
index	fulltext
range	→ ref
index_subquery	→ eq_ref
unique_subquery	→ const
index_merge	system

"const"

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

"const"

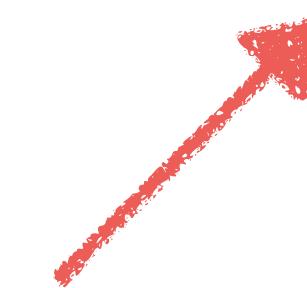
```
SELECT * FROM film  
WHERE film_id = 123;
```



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';
```

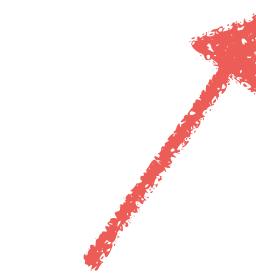


still a ***constant***, but may
match more than one row

"ref"

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

KEY, but not
necessarily unique



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

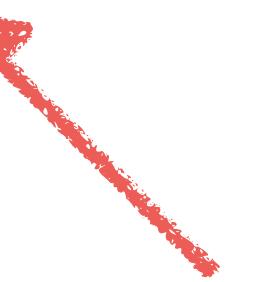


"ref_or_null"

```
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;
```



one pass to
find 'PG-13'

extra pass to find null values

"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

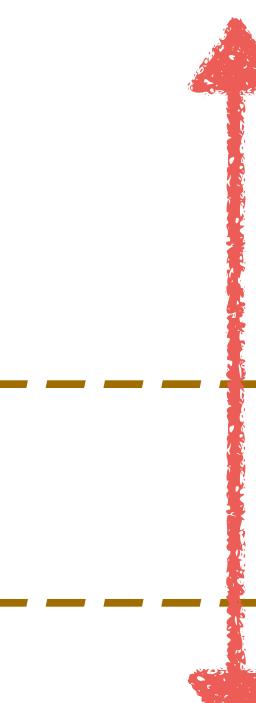
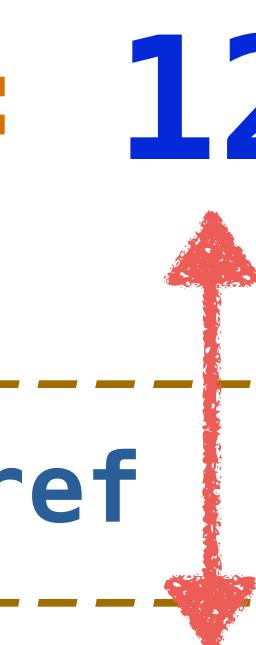
```
SELECT film_id FROM film_actor  
INNER JOIN film USING(film_id)  
WHERE actor_id = 123;
```

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		idx_rating		idx_rating		2		const
+	-	-	-	+	-	-	-	+	-
✓									
+	-	-	-	-	-	-	-	-	-
	rows		Extra						
+	-	-	-	-	-	-	-	-	-
	223		Using index condition; Using filesort						
+	-	-	-	-	-	-	-	-	-

A red arrow points upwards from the bottom row of the table towards the middle row.

✓		✓		✓		✓		✓	
+	-	-	-	+	-	-	-	+	-
type possible_keys key key_len ref									

ref	idx_rating	idx_rating	2	const
+	-	-	-	-

✓									
+	-	-	-	-	-	-	-	-	-
rows Extra									

223	Using index condition; Using filesort
+	-



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 Using index condition	+-----+-----+-----+-----+-----+-----+					

These films are rated PG-13!

[HOTEL HAPPINESS](/film/435)

[MATRIX SNOWMAN](/film/565)

[VICTORY ACADEMY](/film/940)

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; 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

```
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	0K

Data_length: **196608**

Index_length: **147456**

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

(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**

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

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

$$\begin{array}{r} 16384 \\ \div 196608 \\ \hline \approx 8.3\% \end{array}$$

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

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
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

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

+-----+ <th>id</th> <th>select_type</th> <th>table</th> <th>partitions</th> <th>type</th> <th>possible_keys</th> <th>key</th> <th>+-----+</th>	id	select_type	table	partitions	type	possible_keys	key	+-----+
1 SIMPLE film NULL ref idx_rating_title idx_rating_title	+-----+	+-----+	+-----+	+-----+	+-----+	+-----+	+-----+	+-----+

+-----+ <th>key_len</th> <th>ref</th> <th>rows</th> <th>extra</th> <th>+-----+</th>	key_len	ref	rows	extra	+-----+
2 const 223 10.00 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

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

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

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

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

```
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..."

... do this!

```
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.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](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	0.000014
stage/sql/executing	0.000001
stage/sql/Sending data	0.000016
stage/sql/executing	0.000002
stage/sql/Sending data	0.000014
stage/sql/executing	0.000002
stage/sql/Sending data	0.000013
stage/sql/executing	0.000002
stage/sql/Sending data	0.000014
stage/sql/executing	0.000002
stage/sql/Sending data	0.000014
stage/sql/executing	0.000002
stage/sql/Sending data	0.000014
stage/sql/executing	0.000002
stage/sql/Sending data	0.000014
stage/sql/executing	0.000001
stage/sql/Sending data	0.000014
stage/sql/executing	0.000002
stage/sql/Sending data	0.000018
stage/sql/end	0.000003
stage/sql/query end	0.000007
stage/sql/closing tables	0.000008
stage/sql/freeing items	0.000021
stage/sql/cleaning up	0.000001

+-----+
467 rows in set (0.00 sec)

stage/sql/Sending data	0.000014
stage/sql/executing	0.000001
stage/sql/Sending data	0.000016
stage/sql/executing	0.000002
stage/sql/Sending data	0.000014
stage/sql/executing	0.000002
stage/sql/Sending data	0.000013
stage/sql/executing	0.000002
stage/sql/Sending data	0.000014
stage/sql/executing	0.000002
stage/sql/Sending data	0.000014
stage/sql/executing	0.000002
stage/sql/Sending data	0.000014
stage/sql/executing	0.000002
stage/sql/Sending data	0.000014
stage/sql/executing	0.000001
stage/sql/Sending data	0.000014
stage/sql/executing	0.000002
stage/sql/Sending data	0.000018
stage/sql/end	0.000003
stage/sql/query end	0.000007
stage/sql/closing tables	0.000008
stage/sql/freeing items	0.000021
stage/sql/cleaning up	0.000001

!!!

→ 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/aad28>

(in case you missed it...)



Questions?

Thanks!