Отчет по домашнему заданию №2 курса Highload Architect

Содержание отчета

Mysql

DDL Таблицы users:

```
SHOW CREATE TABLE users;
```

```
-----------------------------------------------------------------------------------------------------------------------------------+
| Table | Create Table
|
-----------------------------------------------------------------------------------------------------------------------------------+
| users | CREATE TABLE `users` (
  `user_id` char(36) NOT NULL,
  `first_name` varchar(64) NOT NULL,
  `second_name` varchar(64) DEFAULT NULL,
  `sex` enum('male','female') DEFAULT NULL,
  `biography` text,
  `city` varchar(64) DEFAULT NULL,
  `birthdate` date DEFAULT NULL,
  KEY `users_user_id_index` (`user_id`),
  KEY `users_first_name_second_name_index` (`first_name`,`second_name`)
) ENGINE=InnoDB DEFAULT CHARSET=utf8mb4 COLLATE=utf8mb4_0900_ai_ci |
+-------1 row in set (0.00 sec)
```

```
mysql> SHOW INDEX FROM users;
+-------+------------+----------------------------------+--------------+-------------+-----------+-------------+----------+--------+------+------------+---------+---------------+---------+------------+
| Table | Non_unique | Key_name                         | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-------+------------+----------------------------------+--------------+-------------+-----------+-------------+----------+--------+------+------------+---------+---------------+---------+------------+
| users |          1 | users_user_id_index              |            1 | user_id     | A         |      922210 |     NULL |   NULL |      | BTREE      |         |               | YES     | NULL       |
| users |          1 | users_first_name_second_name_index |            1 | first_name  | A         |         139 |     NULL |   NULL |      | BTREE      |         |               | YES     | NULL       |
| users |          1 | users_first_name_second_name_index |            2 | second_name | A         |       57115 |     NULL |   NULL | YES  | BTREE      |         |               | YES     | NULL       |
+-------+------------+----------------------------------+--------------+-------------+-----------+-------------+----------+--------+------+------------+---------+---------------+---------+------------+
3 rows in set (0.01 sec)
```

До добавления индекса

Explane запроса:

mysql> EXPLAIN select * from users where first_name like 'Иван%' and second_name like 'Бес%';

```
+----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------+
| EXPLAIN                                                                                                                                                                                                                    |
+----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------+
| -> Filter: ((users.first_name like 'Иван%') and (users.second_name like 'Бес%'))  (cost=107914 rows=12264)
    -> Table scan on users  (cost=107914 rows=993595)
       |
+----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------+
1 row in set (0.00 sec)
```

После добавления индекса

Добавление индекса:

mysql> create index users_first_name_second_name_index
    ->   on users (first_name, second_name);
Query OK, 0 rows affected (3.05 sec)
Records: 0 Duplicates: 0 Warnings: 0

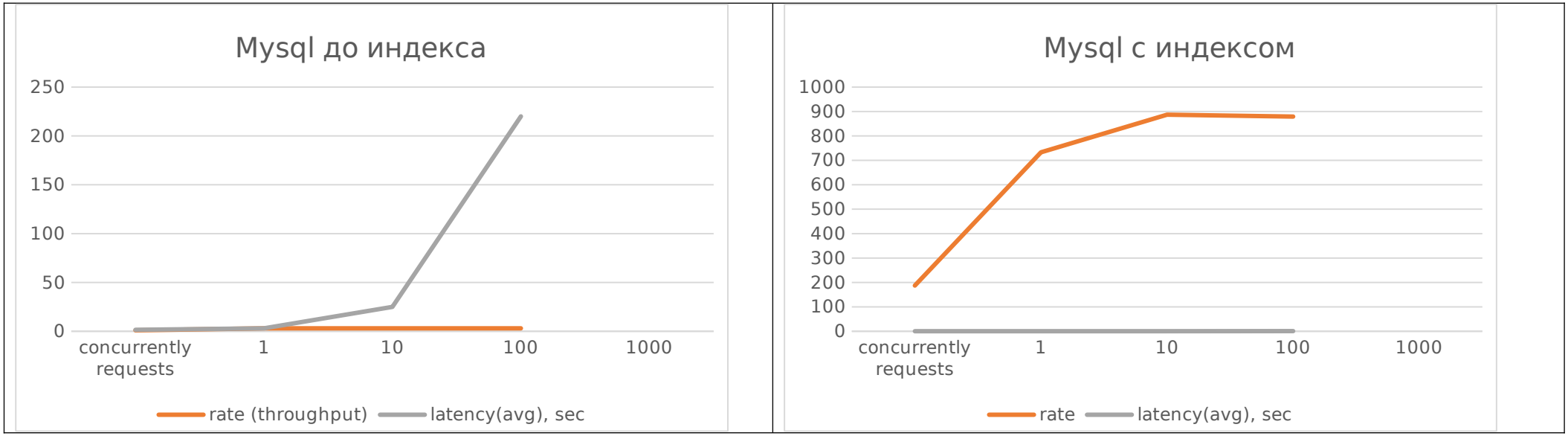
Explane запроса:

```
mysql> EXPLAIN select * from users where first_name like 'Иван%' and second_name like 'Бес%';
+----+-------------+-------+------------+-------+-----------------------------------+-----------------------------------+---------+------+-------+----------+-----------------------------------+
| id | select_type | table | partitions | type  | possible_keys                     | key                               | key_len | ref  | rows  | filtered | Extra                             |
+----+-------------+-------+------------+-------+-----------------------------------+-----------------------------------+---------+------+-------+----------+-----------------------------------+
|  1 | SIMPLE      | users | NULL       | range | users_first_name_second_name_index | users_first_name_second_name_index | 517     | NULL | 37052 |    11.11 | Using index condition; Using MRR |
+----+-------------+-------+------------+-------+-----------------------------------+-----------------------------------+---------+------+-------+----------+-----------------------------------+
```

Таблицы и графики

Mysql					
Without index			With index		
concurrently requests	rate (throughput)	latency(avg), sec	concurrently requests	rate	latency(avg), sec
1	1	1,5	1	187	0,005

10	3	3	10	733	0,012
100	3	25	100	887	0,08
1000	3	220	1000	879	0,76



Выводы

1. Поведение после добавления индекса ожидаемо, explane показывает использование индекса
2. Без использования индекса throughput составляет всего 3 запроса в секунду. После добавления индекса сервер без деградации latency держит примерно до 800 запросов в секунду. После наблюдается увеличение времени отклика.

Вопросы:

1. Как можно увеличить throughput сервера. Вероятно, какими-то настройками, но какими?

Приложение 1 – лог запросов до добавления индекса

```
hey -n 10 -c 1 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес'
```

```
Summary:
  Total:       15.1099 secs
  Slowest:     1.5226 secs
  Fastest:     1.4996 secs
  Average:     1.5110 secs
  Requests/sec:       0.6618


Response time histogram:
  1.500 [1]    |■■■■■■■■■■■■■■■■■■■■
  1.502 [1]    |■■■■■■■■■■■■■■■■■■■■
  1.504 [1]    |■■■■■■■■■■■■■■■■■■■■
  1.506 [0]    |
  1.509 [0]    |
  1.511 [2]    |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  1.513 [0]    |
  1.516 [2]    |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  1.518 [1]    |■■■■■■■■■■■■■■■■■■■■
  1.520 [1]    |■■■■■■■■■■■■■■■■■■■■
  1.523 [1]    |■■■■■■■■■■■■■■■■■■■■


Latency distribution:
  10% in 1.4997 secs
  25% in 1.5100 secs
  50% in 1.5138 secs
  75% in 1.5186 secs
  90% in 1.5226 secs
  0% in 0.0000 secs
  0% in 0.0000 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0000 secs, 1.4996 secs, 1.5226 secs
  DNS-lookup:  0.0000 secs, 0.0000 secs, 0.0001 secs
  req write:   0.0000 secs, 0.0000 secs, 0.0001 secs
  resp wait:   1.5108 secs, 1.4995 secs, 1.5225 secs
  resp read:   0.0001 secs, 0.0001 secs, 0.0001 secs

Status code distribution:
  [200] 10 responses



hey -n 100 -c 10 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес' >>mysql.log

Summary:
  Total:       32.6865 secs
  Slowest:     6.5508 secs
  Fastest:     1.6266 secs
  Average:     3.0561 secs
  Requests/sec:       3.0594


Response time histogram:
```

```
  1.627 [1]    |■
  2.119 [34]   |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  2.611 [0]    |
  3.104 [0]    |
  3.596 [48]   |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  4.089 [0]    |
  4.581 [0]    |
  5.074 [12]   |■■■■■■■■■■
  5.566 [0]    |
  6.058 [0]    |
  6.551 [5]    |■■■■


Latency distribution:
  10% in 1.6340 secs
  25% in 1.6385 secs
  50% in 3.2664 secs
  75% in 3.2776 secs
  90% in 4.9008 secs
  95% in 6.5221 secs
  99% in 6.5508 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0001 secs, 1.6266 secs, 6.5508 secs
  DNS-lookup:  0.0000 secs, 0.0000 secs, 0.0004 secs
  req write:   0.0000 secs, 0.0000 secs, 0.0003 secs
  resp wait:   3.0560 secs, 1.6265 secs, 6.5501 secs
  resp read:   0.0000 secs, 0.0000 secs, 0.0001 secs

Status code distribution:
  [200] 100 responses




hey -n 1000 -c 100 -t 0 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес' >>mysql.log

Summary:
  Total:       337.3888 secs
  Slowest:     297.5786 secs
  Fastest:     1.5543 secs
  Average:     25.2815 secs
  Requests/sec:       2.9639


Response time histogram:
  1.554 [1]    |
  31.157 [779] |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  60.759 [121] |■■■■■■
  90.362 [40]  |■■
  119.964 [20] |■
  149.566 [11] |■
  179.169 [11] |■
  208.771 [7]  |
  238.374 [1]  |
```

```
  267.976 [6]  |
  297.579 [3]  |


Latency distribution:
  10% in 3.3414 secs
  25% in 5.0195 secs
  50% in 11.4449 secs
  75% in 26.8221 secs
  90% in 60.3494 secs
  95% in 106.0476 secs
  99% in 234.8641 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0006 secs, 1.5543 secs, 297.5786 secs
  DNS-lookup:  0.0001 secs, 0.0000 secs, 0.0088 secs
  req write:   0.0001 secs, 0.0000 secs, 0.0068 secs
  resp wait:   25.2806 secs, 1.5542 secs, 297.5786 secs
  resp read:   0.0000 secs, 0.0000 secs, 0.0004 secs

Status code distribution:
  [200] 1000 responses
```

```
hey -n 3000 -c 1000 -t 0 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес'

Summary:
  Total:       987.2750 secs
  Slowest:     982.3998 secs
  Fastest:     1.5457 secs
  Average:     220.2241 secs
  Requests/sec:       3.0387


Response time histogram:
  1.546 [1]    |
  99.631 [1234]       |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  197.717 [579]       |■■■■■■■■■■■■■■■■■■■
  295.802 [327]       |■■■■■■■■■■■
  393.887 [242]       |■■■■■■■■
  491.973 [203]       |■■■■■■■
  590.058 [143]       |■■■■■
  688.144 [101]       |■■■
  786.229 [83] |■■■
  884.314 [51] |■■
  982.400 [36] |■


Latency distribution:
  10% in 10.0489 secs
  25% in 43.0538 secs
  50% in 141.9484 secs
  75% in 339.4502 secs
```

```
  90% in 564.8947 secs
  95% in 705.6155 secs
  99% in 906.5254 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0209 secs, 1.5457 secs, 982.3998 secs
  DNS-lookup:  0.0066 secs, 0.0000 secs, 0.1053 secs
  req write:   0.0068 secs, 0.0000 secs, 0.0609 secs
  resp wait:   220.1956 secs, 1.5456 secs, 982.2938 secs
  resp read:   0.0000 secs, 0.0000 secs, 0.0003 secs

Status code distribution:
  [200] 3000 responses
```

Приложение 2 – лог запросов после добавления индекса

```
hey -n 10 -c 1 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес'

Summary:
  Total:       0.0534 secs
  Slowest:     0.0064 secs
  Fastest:     0.0049 secs
  Average:     0.0053 secs
  Requests/sec:       187.4118


Response time histogram:
  0.005 [1]    |■■■■■■■■■■■■■
  0.005 [3]    |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.005 [2]    |■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.005 [0]    |
  0.005 [2]    |■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.006 [0]    |
  0.006 [0]    |
  0.006 [0]    |
  0.006 [0]    |
  0.006 [0]    |
  0.006 [2]    |■■■■■■■■■■■■■■■■■■■■■■■■■■■


Latency distribution:
  10% in 0.0049 secs
  25% in 0.0050 secs
  50% in 0.0051 secs
  75% in 0.0063 secs
  90% in 0.0064 secs
  0% in 0.0000 secs
  0% in 0.0000 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0000 secs, 0.0049 secs, 0.0064 secs
  DNS-lookup:  0.0000 secs, 0.0000 secs, 0.0002 secs
  req write:   0.0000 secs, 0.0000 secs, 0.0000 secs
  resp wait:   0.0052 secs, 0.0048 secs, 0.0062 secs
```

```
  resp read:   0.0000 secs, 0.0000 secs, 0.0001 secs

Status code distribution:
  [200] 10 responses



hey -n 100 -c 10 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес'

Summary:
  Total:       0.1364 secs
  Slowest:     0.0399 secs
  Fastest:     0.0051 secs
  Average:     0.0117 secs
  Requests/sec:       733.3615


Response time histogram:
  0.005 [1]    |■
  0.009 [26]   |■■■■■■■■■■■■■■■■■■■■■■■■■
  0.012 [42]   |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.016 [16]   |■■■■■■■■■■■■■■■■
  0.019 [3]    |■■■
  0.022 [6]    |■■■■■■
  0.026 [3]    |■■■
  0.029 [1]    |■
  0.033 [1]    |■
  0.036 [0]    |
  0.040 [1]    |■


Latency distribution:
  10% in 0.0056 secs
  25% in 0.0082 secs
  50% in 0.0101 secs
  75% in 0.0140 secs
  90% in 0.0206 secs
  95% in 0.0253 secs
  99% in 0.0399 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0001 secs, 0.0051 secs, 0.0399 secs
  DNS-lookup:  0.0000 secs, 0.0000 secs, 0.0005 secs
  req write:   0.0000 secs, 0.0000 secs, 0.0002 secs
  resp wait:   0.0115 secs, 0.0050 secs, 0.0399 secs
  resp read:   0.0000 secs, 0.0000 secs, 0.0001 secs

Status code distribution:
  [200] 100 responses



hey -n 1000 -c 100 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес'
Summary:
  Total:       1.1261 secs
```

```
  Slowest:     0.9258 secs
  Fastest:     0.0050 secs
  Average:     0.0839 secs
  Requests/sec:        887.9856


Response time histogram:
  0.005 [1]    |
  0.097 [775]  |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.189 [112]  |■■■■■■
  0.281 [42]   |■■
  0.373 [23]   |■
  0.465 [16]   |■
  0.557 [6]    |
  0.650 [6]    |
  0.742 [10]   |■
  0.834 [4]    |
  0.926 [5]    |


Latency distribution:
  10% in 0.0087 secs
  25% in 0.0139 secs
  50% in 0.0323 secs
  75% in 0.0866 secs
  90% in 0.2173 secs
  95% in 0.3598 secs
  99% in 0.7354 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0002 secs, 0.0050 secs, 0.9258 secs
  DNS-lookup:  0.0000 secs, 0.0000 secs, 0.0019 secs
  req write:   0.0001 secs, 0.0000 secs, 0.0027 secs
  resp wait:   0.0836 secs, 0.0049 secs, 0.9257 secs
  resp read:   0.0000 secs, 0.0000 secs, 0.0003 secs

Status code distribution:
  [200] 1000 responses



hey -n 3000 -c 1000 -t 0 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес'

Summary:
  Total:       3.4099 secs
  Slowest:     3.3577 secs
  Fastest:     0.0049 secs
  Average:     0.7616 secs
  Requests/sec:        879.7935


Response time histogram:
  0.005 [1]    |
  0.340 [1186] |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.675 [558]  |■■■■■■■■■■■■■■■■■■■
```

```
  1.011 [393]  |■■■■■■■■■■■■■
  1.346 [267]  |■■■■■■■■■
  1.681 [203]  |■■■■■■■
  2.017 [137]  |■■■■■
  2.352 [93]   |■■■
  2.687 [73]   |■■
  3.022 [58]   |■■
  3.358 [31]   |■


Latency distribution:
  10% in 0.0422 secs
  25% in 0.1712 secs
  50% in 0.5103 secs
  75% in 1.1308 secs
  90% in 1.9137 secs
  95% in 2.4300 secs
  99% in 3.0357 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0093 secs, 0.0049 secs, 3.3577 secs
  DNS-lookup:  0.0062 secs, 0.0000 secs, 0.0862 secs
  req write:   0.0014 secs, 0.0000 secs, 0.0529 secs
  resp wait:   0.7445 secs, 0.0049 secs, 3.3091 secs
  resp read:   0.0003 secs, 0.0000 secs, 0.0522 secs

Status code distribution:
  [200] 3000 responses
```

Postgres

DDL Таблицы users:

```
\d users
                            Table "public.users"
   Column    |            Type             | Collation | Nullable | Default
-------------+-----------------------------+-----------+----------+---------
 user_id     | character(36)               |           | not null |
 first_name  | character varying(64)       |           | not null |
 second_name | character varying(64)       |           |          |
 sex         | sex_status                  |           |          |
 biography   | text                        |           |          |
 city        | character varying(64)       |           |          |
 birthdate   | timestamp without time zone |           |          |
Indexes:
    "users_pkey" PRIMARY KEY, btree (user_id)
    "users_first_name_second_name_index" btree (first_name, second_name)
Referenced by:
    TABLE "token" CONSTRAINT "tokens_user_id_fkey" FOREIGN KEY (user_id) REFERENCES users(user_id) ON DELETE CASCADE
    TABLE "user_credentials" CONSTRAINT "user_credentials_user_id_fkey" FOREIGN KEY (user_id) REFERENCES users(user_id) ON DELETE CASCADE
```

До добавления индекса

```
snet=# EXPLAIN select * from users where first_name like 'Иван%' and second_name like 'Бес%';
                                QUERY PLAN
---------------------------------------------------------------------------------------------
 Gather  (cost=1000.00..22590.04 rows=133 width=128)
   Workers Planned: 2
   ->  Parallel Seq Scan on users  (cost=0.00..21576.74 rows=55 width=128)
```

```
        Filter: (((first_name)::text ~~ 'Иван%'::text) AND ((second_name)::text ~~ 'Бес%'::text))
(4 rows)
```

После добавления индекса

Добавление индекса:

```
snet=# create index users_first_name_second_name_index
    on public.users (first_name, second_name);
CREATE INDEX
```

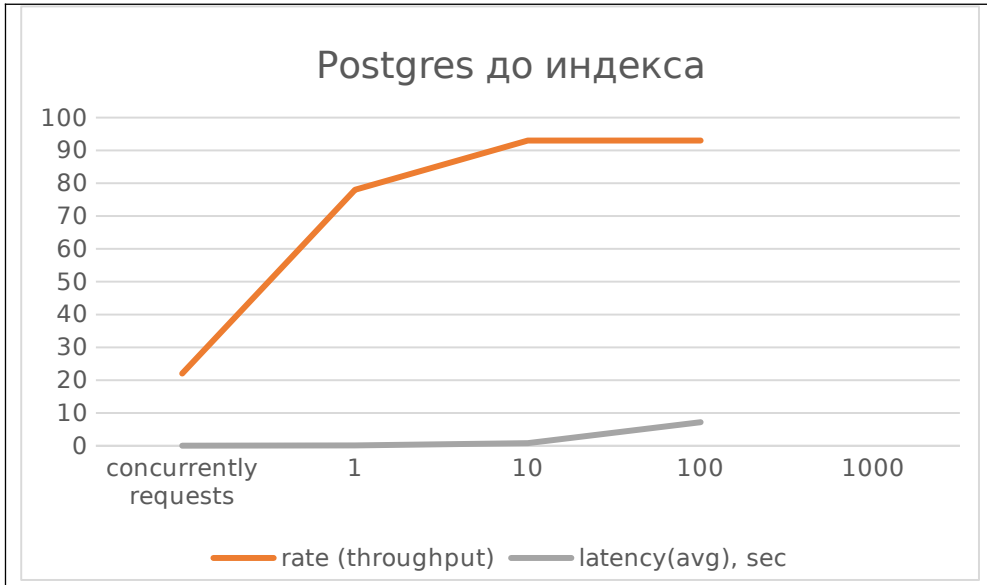
Explane запроса:

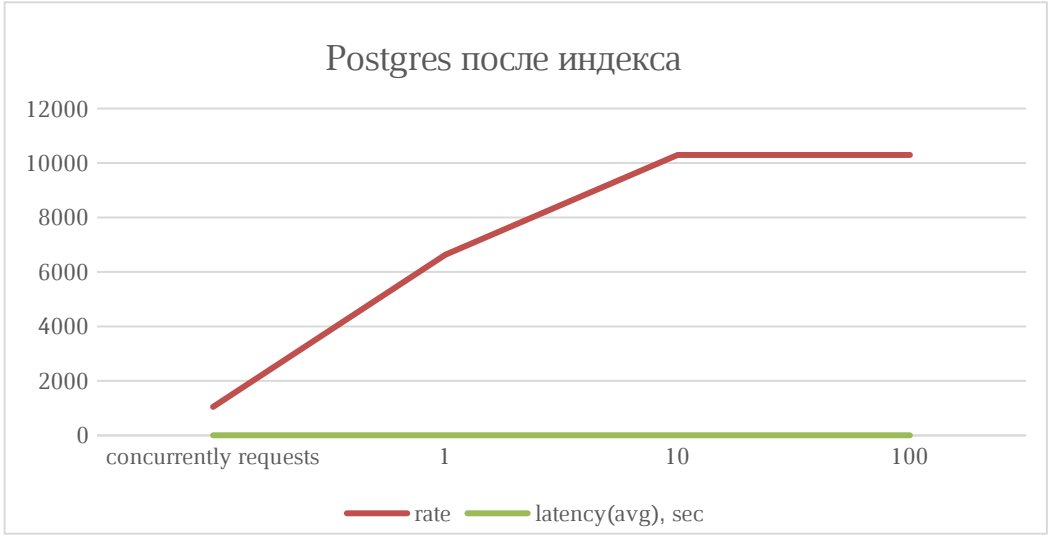
```
\l snet
                                        List of databases
 Name |  Owner   | Encoding | Collate | Ctype | ICU Locale | Locale Provider | Access privileges
------+----------+----------+---------+-------+------------+-----------------+-------------------
 snet | postgres | UTF8     | C       | C     |            | libc            |
(1 row)

snet=# EXPLAIN analyze select first_name from users where first_name like 'ИваН%' and second_name like 'Бес%';
                                                                   QUERY PLAN
-----------------------------------------------------------------------------------------------------------------------------------------------------
 Index Only Scan using users_first_name_second_name_index on users  (cost=0.42..411.94 rows=1 width=13) (actual time=0.077..0.188 rows=21 loops=1)
   Index Cond: ((first_name >= 'Иван'::text) AND (first_name < 'Ивао'::text) AND (second_name >= 'Бес'::text) AND (second_name < 'Бет'::text))
   Filter: ((first_name ~~ 'Иван%'::text) AND (second_name ~~ 'Бес%'::text))
   Heap Fetches: 0
 Planning Time: 0.129 ms
 Execution Time: 0.230 ms
(6 rows)
```

Таблицы и графики

Postgres					
Without index			With index		
concurrently requests	rate (throughput)	latency(avg), sec	concurrently requests	rate	latency(avg), sec
1	22	0,04	1	1046	0,001
10	78	0,11	10	6632	0,014

100	93	0,78	100	10300	0,007
1000	93	7,2	1000	10300	0.07





Выводы

1. Postgres использует созданный индекс, однако для того, чтобы он это сделал в необходимо для БД установить lc_collate = C
2. До создания индекса запросы выполнялись на порядки быстрее чем с mysql(тоже без индекса)
3. Результаты намного превосходит результаты mysql(на порядок) в throughput 10000 vs 800 и latency
4. Деградация, выражающаяся в значительном увеличении latency в принципе не наблюдалась.
5. Оказывается для выражений like и операций сравнения необходимо устанавливать collation. lc_collate = C как универсальный описан в блоге https://simply.name/ru/pg-lc-collate.html

Приложение 1 – лог запросов до добавления индекса

```
hey -n 10 -c 1 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес'

Summary:
  Total:       0.4513 secs
  Slowest:     0.1454 secs
  Fastest:     0.0315 secs
  Average:     0.0451 secs
  Requests/sec:       22.1604


Response time histogram:
  0.031 [1]    |■■■■■
  0.043 [8]    |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.054 [0]    |
  0.066 [0]    |
  0.077 [0]    |
  0.088 [0]    |
  0.100 [0]    |
  0.111 [0]    |
  0.123 [0]    |
  0.134 [0]    |
  0.145 [1]    |■■■■■


Latency distribution:
  10% in 0.0318 secs
  25% in 0.0321 secs
  50% in 0.0338 secs
  75% in 0.0421 secs
  90% in 0.1454 secs
  0% in 0.0000 secs
  0% in 0.0000 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0000 secs, 0.0315 secs, 0.1454 secs
  DNS-lookup:  0.0000 secs, 0.0000 secs, 0.0003 secs
  req write:   0.0000 secs, 0.0000 secs, 0.0001 secs
  resp wait:   0.0449 secs, 0.0313 secs, 0.1447 secs
  resp read:   0.0001 secs, 0.0000 secs, 0.0001 secs

Status code distribution:
  [200] 10 responses


hey -n 100 -c 10 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес'

Summary:
  Total:       1.2690 secs
  Slowest:     0.3524 secs
```

```
  Fastest:     0.0298 secs
  Average:     0.1126 secs
  Requests/sec:       78.8030


Response time histogram:
  0.030 [1]    |■
  0.062 [19]   |■■■■■■■■■■■■■■■■■■■■■■■■■
  0.094 [31]   |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.127 [21]   |■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.159 [7]    |■■■■■■■■■
  0.191 [9]    |■■■■■■■■■■■■
  0.223 [6]    |■■■■■■■■
  0.256 [0]    |
  0.288 [3]    |■■■■
  0.320 [1]    |■
  0.352 [2]    |■■■


Latency distribution:
  10% in 0.0529 secs
  25% in 0.0712 secs
  50% in 0.0943 secs
  75% in 0.1440 secs
  90% in 0.2013 secs
  95% in 0.2603 secs
  99% in 0.3524 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0000 secs, 0.0298 secs, 0.3524 secs
  DNS-lookup:  0.0000 secs, 0.0000 secs, 0.0006 secs
  req write:   0.0000 secs, 0.0000 secs, 0.0001 secs
  resp wait:   0.1124 secs, 0.0297 secs, 0.3517 secs
  resp read:   0.0001 secs, 0.0000 secs, 0.0001 secs

Status code distribution:
  [200] 100 responses


hey -n 1000 -c 100 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес'

Summary:
  Total:       10.7142 secs
  Slowest:     9.0241 secs
  Fastest:     0.0318 secs
  Average:     0.7837 secs
  Requests/sec:       93.3339


Response time histogram:
  0.032 [1]    |
  0.931 [768]  |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  1.830 [137]  |■■■■■■■
  2.729 [43]   |■■
  3.629 [14]   |■
```

```
  4.528 [6]    |
  5.427 [3]    |
  6.326 [7]    |
  7.226 [7]    |
  8.125 [10]   |■
  9.024 [4]    |


Latency distribution:
  10% in 0.0814 secs
  25% in 0.1269 secs
  50% in 0.3089 secs
  75% in 0.8841 secs
  90% in 1.7725 secs
  95% in 2.8852 secs
  99% in 7.5123 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0003 secs, 0.0318 secs, 9.0241 secs
  DNS-lookup:  0.0000 secs, 0.0000 secs, 0.0026 secs
  req write:   0.0001 secs, 0.0000 secs, 0.0058 secs
  resp wait:   0.7831 secs, 0.0317 secs, 9.0182 secs
  resp read:   0.0001 secs, 0.0000 secs, 0.0002 secs

Status code distribution:
  [200] 1000 responses



hey -n 3000 -c 1000 -t 0 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес'

Summary:
  Total:       32.2619 secs
  Slowest:     32.0809 secs
  Fastest:     0.0443 secs
  Average:     7.2458 secs
  Requests/sec:       92.9890


Response time histogram:
  0.044 [1]    |
  3.248 [1206] |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  6.452 [548]  |■■■■■■■■■■■■■■■■■■
  9.655 [377]  |■■■■■■■■■■■■■
  12.859 [267] |■■■■■■■■■
  16.063 [188] |■■■■■■
  19.266 [150] |■■■■■
  22.470 [110] |■■■■
  25.674 [78]  |■■■
  28.877 [48]  |■■
  32.081 [27]  |■


Latency distribution:
  10% in 0.4512 secs
```

```
  25% in 1.5501 secs
  50% in 4.6728 secs
  75% in 11.0035 secs
  90% in 18.3749 secs
  95% in 22.5326 secs
  99% in 28.8461 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0314 secs, 0.0443 secs, 32.0809 secs
  DNS-lookup:  0.0217 secs, 0.0000 secs, 0.1522 secs
  req write:   0.0030 secs, 0.0000 secs, 0.1451 secs
  resp wait:   7.2083 secs, 0.0437 secs, 31.9330 secs
  resp read:   0.0001 secs, 0.0000 secs, 0.0083 secs

Status code distribution:
  [200] 3000 responses
```

Приложение 2 – лог запросов после добавления индекса

```
\l snet
                                        List of databases
 Name |  Owner   | Encoding | Collate | Ctype | ICU Locale | Locale Provider | Access privileges
------+----------+----------+---------+-------+------------+-----------------+-------------------
 snet | postgres | UTF8     | C       | C     |            | libc            |
(1 row)

snet=# EXPLAIN analyze select first_name from users where first_name like 'ИваН%' and second_name like 'Бес%';
                                                                   QUERY PLAN
-----------------------------------------------------------------------------------------------------------------------------------------------------
 Index Only Scan using users_first_name_second_name_index on users  (cost=0.42..411.94 rows=1 width=13) (actual time=0.077..0.188 rows=21 loops=1)
   Index Cond: ((first_name >= 'Иван'::text) AND (first_name < 'Ивао'::text) AND (second_name >= 'Бес'::text) AND (second_name < 'Бет'::text))
   Filter: ((first_name ~~ 'Иван%'::text) AND (second_name ~~ 'Бес%'::text))
   Heap Fetches: 0
 Planning Time: 0.129 ms
 Execution Time: 0.230 ms
(6 rows)


hey -n 10 -c 1 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес'

Summary:
  Total:        0.0096 secs
  Slowest:      0.0053 secs
  Fastest:      0.0004 secs
  Average:      0.0010 secs
  Requests/sec:        1046.0352


Response time histogram:
  0.000 [1]     |■■■■■
```

```
  0.001 [8]	|■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.001 [0]	|
  0.002 [0]	|
  0.002 [0]	|
  0.003 [0]	|
  0.003 [0]	|
  0.004 [0]	|
  0.004 [0]	|
  0.005 [0]	|
  0.005 [1]	|■■■■■


Latency distribution:
  10% in 0.0004 secs
  25% in 0.0004 secs
  50% in 0.0005 secs
  75% in 0.0006 secs
  90% in 0.0053 secs
  0% in 0.0000 secs
  0% in 0.0000 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0000 secs, 0.0004 secs, 0.0053 secs
  DNS-lookup:  0.0000 secs, 0.0000 secs, 0.0002 secs
  req write:   0.0000 secs, 0.0000 secs, 0.0001 secs
  resp wait:   0.0008 secs, 0.0004 secs, 0.0046 secs
  resp read:   0.0000 secs, 0.0000 secs, 0.0001 secs

Status code distribution:
  [200]	10 responses



hey -n 100 -c 10 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес'

Summary:
  Total:	0.0151 secs
  Slowest:	0.0068 secs
  Fastest:	0.0005 secs
  Average:	0.0014 secs
  Requests/sec:	6632.2334


Response time histogram:
  0.000 [1]	|■
  0.001 [67]	|■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.002 [18]	|■■■■■■■■■■■
  0.002 [4]	|■■
  0.003 [2]	|■
  0.004 [1]	|■
  0.004 [1]	|■
  0.005 [1]	|■
  0.006 [2]	|■
  0.006 [2]	|■
  0.007 [1]	|■
```

```
Latency distribution:
  10% in 0.0007 secs
  25% in 0.0008 secs
  50% in 0.0010 secs
  75% in 0.0012 secs
  90% in 0.0024 secs
  95% in 0.0053 secs
  99% in 0.0068 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0000 secs, 0.0005 secs, 0.0068 secs
  DNS-lookup:  0.0000 secs, 0.0000 secs, 0.0004 secs
  req write:   0.0000 secs, 0.0000 secs, 0.0001 secs
  resp wait:   0.0013 secs, 0.0004 secs, 0.0064 secs
  resp read:   0.0000 secs, 0.0000 secs, 0.0001 secs

Status code distribution:
  [200] 100 responses



hey -n 1000 -c 100 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес'

Summary:
  Total:        0.0970 secs
  Slowest:      0.0643 secs
  Fastest:      0.0005 secs
  Average:      0.0077 secs
  Requests/sec:        10314.2879


Response time histogram:
  0.000 [1]     |
  0.007 [651]   |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.013 [171]   |■■■■■■■■■■■
  0.020 [74]    |■■■■■
  0.026 [52]    |■■■
  0.032 [26]    |■■
  0.039 [14]    |■
  0.045 [6]     |
  0.052 [2]     |
  0.058 [1]     |
  0.064 [2]     |


Latency distribution:
  10% in 0.0011 secs
  25% in 0.0020 secs
  50% in 0.0046 secs
  75% in 0.0096 secs
  90% in 0.0202 secs
  95% in 0.0262 secs
```

```
  99% in 0.0403 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0000 secs, 0.0005 secs, 0.0643 secs
  DNS-lookup:  0.0001 secs, 0.0000 secs, 0.0048 secs
  req write:   0.0001 secs, 0.0000 secs, 0.0059 secs
  resp wait:   0.0072 secs, 0.0004 secs, 0.0604 secs
  resp read:   0.0001 secs, 0.0000 secs, 0.0044 secs

Status code distribution:
  [200] 1000 responses



hey -n 10000 -c 1000 -m GET 'http://localhost:8800/user/search?first_name=Иван&second_name=Бес'

Summary:
  Total:       0.9630 secs
  Slowest:     0.8537 secs
  Fastest:     0.0004 secs
  Average:     0.0764 secs
  Requests/sec:       10384.3685


Response time histogram:
  0.000 [1]    |
  0.086 [6847] |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.171 [1942] |■■■■■■■■■■■
  0.256 [625]  |■■■■
  0.342 [265]  |■■
  0.427 [147]  |■
  0.512 [93]   |■
  0.598 [39]   |
  0.683 [31]   |
  0.768 [7]    |
  0.854 [3]    |


Latency distribution:
  10% in 0.0026 secs
  25% in 0.0097 secs
  50% in 0.0399 secs
  75% in 0.1017 secs
  90% in 0.1936 secs
  95% in 0.2787 secs
  99% in 0.4865 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0010 secs, 0.0004 secs, 0.8537 secs
  DNS-lookup:  0.0031 secs, 0.0000 secs, 0.1530 secs
  req write:   0.0013 secs, 0.0000 secs, 0.1017 secs
  resp wait:   0.0668 secs, 0.0004 secs, 0.7459 secs
  resp read:   0.0010 secs, 0.0000 secs, 0.0965 secs
```

```
Status code distribution:
  [200] 10000 responses
```