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

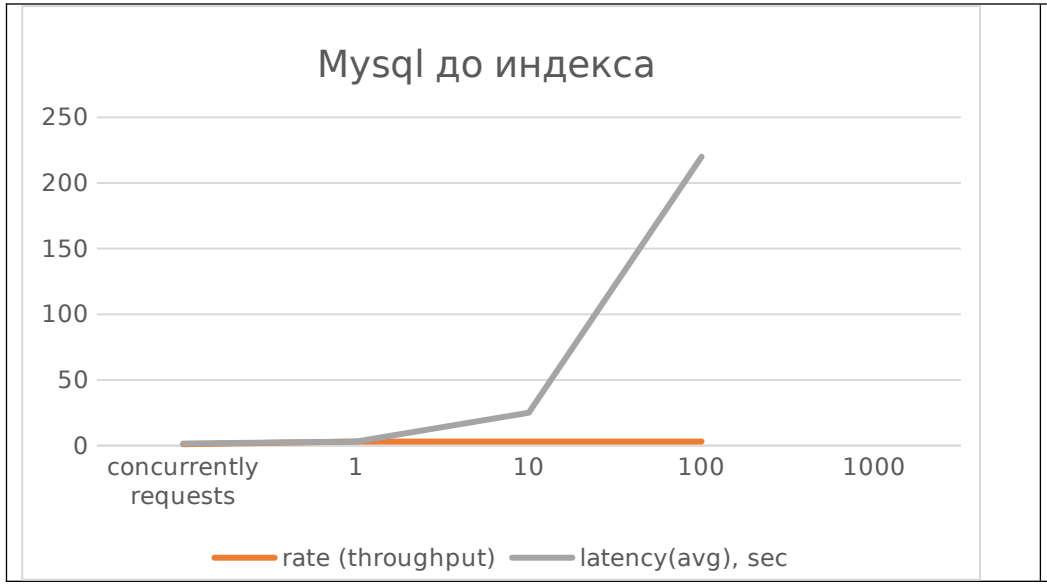
Explane запроса:

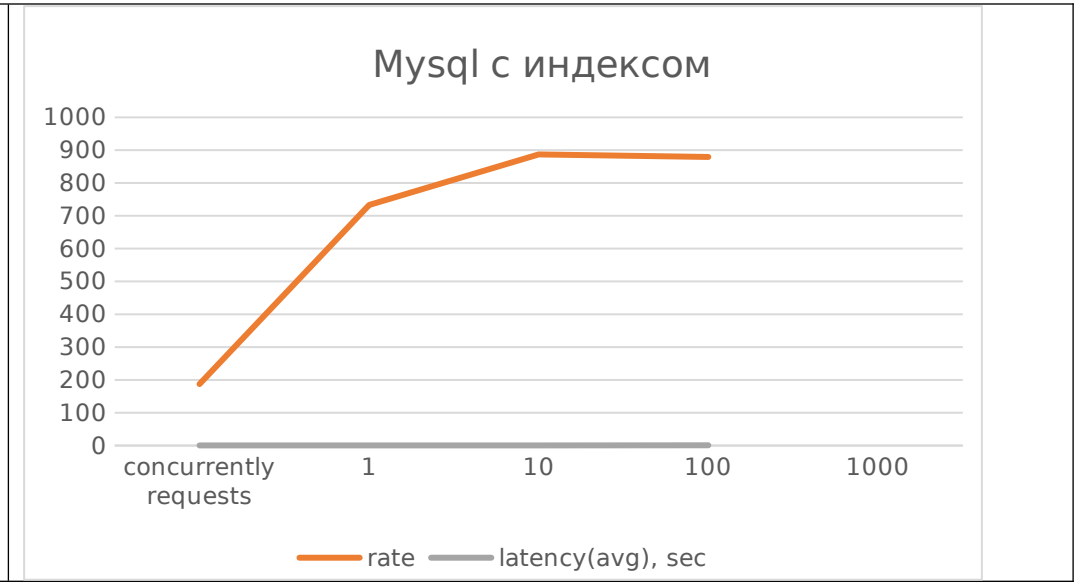
```
mysql> EXPLAIN select * from users where first_name like 'Иван%' and second_name like 'Бес%';
+----+-------------+-------+------------+-------+-----------------------------------+-----------------------------------+---------+------+-------+----------+-----------------------------------+
| id | select_type | 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:

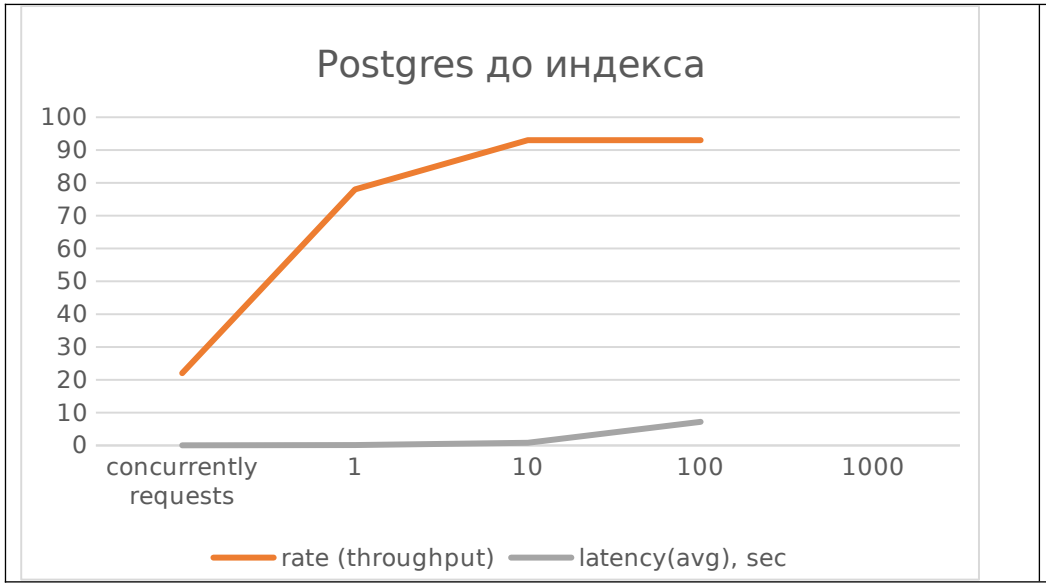
```
snet=# create index users_first_name_second_name_index
   on public.users (first_name, second_name);
CREATE INDEX
```

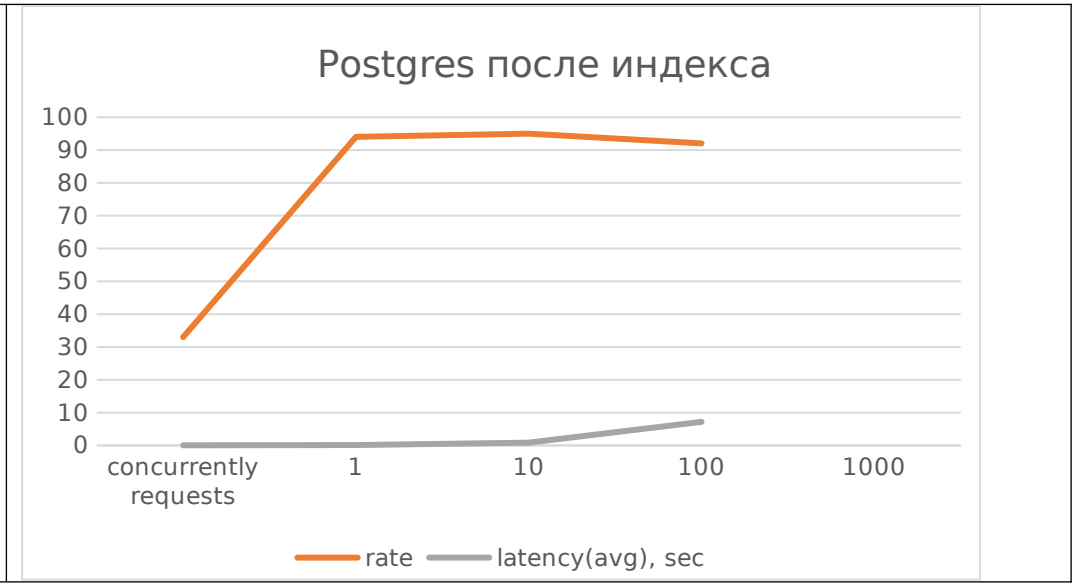
Explane запроса:

```
EXPLAIN analyze select first_name from users where first_name like 'ИваН%' and second_name like 'Бес%';
                                                        QUERY PLAN
---------------------------------------------------------------------------------------------------------------------------
 Gather  (cost=1000.00..22578.10 rows=1 width=13) (actual time=24.320..29.112 rows=0 loops=1)
   Workers Planned: 2
   Workers Launched: 2
   ->  Parallel Seq Scan on users  (cost=0.00..21578.00 rows=1 width=13) (actual time=22.741..22.743 rows=0 loops=3)
         Filter: (((first_name)::text ~~ 'ИваН%'::text) AND ((second_name)::text ~~ 'Бес%'::text))
         Rows Removed by Filter: 333333
 Planning Time: 0.105 ms
 Execution Time: 29.127 ms
(8 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	33	0,029
10	78	0,11	10	94	0,096
100	93	0,78	100	95	0,83
1000	93	7,2	1000	92	7,2





Выводы

1. Postgres не использует созданный индекс, хотя по идее должен.
2. До создания индекса запросы выполнялись на порядки быстрее чем с mysql(тоже без индекса)
3. Ввиду того, что postgres по какой-то причине не использует предложенный ему индекс, оценить время запроса с использованием индекса не представляется возможным.
4. Деградация, выражающаяся в увеличении latency наблюдается при throughput близким к 90 запросов в секунду.

Вопросы:

1. Как можно увеличить throughput сервера. Вероятно, какими-то настройками, но какими?
2. Как заставить postgres использовать индекс?
3. Почему mysql заметно проигрывает postgres без использования индекса?

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

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

Summary:
  Total:       0.2968 secs
  Slowest:     0.0308 secs
  Fastest:     0.0291 secs
  Average:     0.0297 secs
  Requests/sec:       33.6969


Response time histogram:
  0.029 [1]    |■■■■■■■■■■■■■■■■■■■■
  0.029 [2]    |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.029 [1]    |■■■■■■■■■■■■■■■■■■■■
  0.030 [1]    |■■■■■■■■■■■■■■■■■■■■
  0.030 [2]    |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.030 [0]    |
  0.030 [2]    |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.030 [0]    |
  0.030 [0]    |
  0.031 [0]    |
  0.031 [1]    |■■■■■■■■■■■■■■■■■■■■


Latency distribution:
  10% in 0.0293 secs
  25% in 0.0293 secs
  50% in 0.0297 secs
  75% in 0.0301 secs
  90% in 0.0308 secs
  0% in 0.0000 secs
  0% in 0.0000 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0000 secs, 0.0291 secs, 0.0308 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:   0.0295 secs, 0.0290 secs, 0.0301 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:        1.0527 secs
  Slowest:      0.3370 secs
  Fastest:      0.0294 secs
  Average:      0.0964 secs
  Requests/sec:        94.9944


Response time histogram:
  0.029 [1]     |■
  0.060 [22]    |■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.091 [33]    |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.122 [24]    |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  0.152 [10]    |■■■■■■■■■■■■
  0.183 [3]     |■■■■
  0.214 [3]     |■■■■
  0.245 [2]     |■■
  0.275 [1]     |■
  0.306 [0]     |
  0.337 [1]     |■


Latency distribution:
  10% in 0.0484 secs
  25% in 0.0625 secs
  50% in 0.0874 secs
  75% in 0.1180 secs
  90% in 0.1595 secs
  95% in 0.2089 secs
  99% in 0.3370 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0001 secs, 0.0294 secs, 0.3370 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:   0.0962 secs, 0.0293 secs, 0.3369 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:        10.5230 secs
  Slowest:      8.5217 secs
```

```
  Fastest:     0.0294 secs
  Average:     0.8302 secs
  Requests/sec:       95.0295


Response time histogram:
  0.029 [1]    |
  0.879 [705]  |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  1.728 [163]  |■■■■■■■■■
  2.577 [63]   |■■■■
  3.426 [32]   |■■
  4.276 [12]   |■
  5.125 [11]   |■
  5.974 [7]    |
  6.823 [2]    |
  7.672 [2]    |
  8.522 [2]    |


Latency distribution:
  10% in 0.0856 secs
  25% in 0.1748 secs
  50% in 0.4464 secs
  75% in 1.0328 secs
  90% in 2.0266 secs
  95% in 3.0012 secs
  99% in 5.4025 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0006 secs, 0.0294 secs, 8.5217 secs
  DNS-lookup:  0.0000 secs, 0.0000 secs, 0.0058 secs
  req write:   0.0004 secs, 0.0000 secs, 0.0162 secs
  resp wait:   0.8290 secs, 0.0293 secs, 8.5095 secs
  resp read:   0.0001 secs, 0.0000 secs, 0.0007 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:       32.5069 secs
  Slowest:     31.8757 secs
  Fastest:     0.0455 secs
  Average:     7.2273 secs
  Requests/sec:       92.2882


Response time histogram:
  0.046 [1]    |
  3.229 [1234] |■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■■
  6.412 [541]  |■■■■■■■■■■■■■■■■■■
  9.595 [365]  |■■■■■■■■■■■■
```

```
  12.778 [249] |■■■■■■■■
  15.961 [175] |■■■■■■
  19.144 [156] |■■■■■
  22.327 [105] |■■■
  25.510 [84]  |■■■
  28.693 [61]  |■■
  31.876 [29]  |■


Latency distribution:
  10% in 0.4366 secs
  25% in 1.4828 secs
  50% in 4.5984 secs
  75% in 10.8024 secs
  90% in 18.6579 secs
  95% in 23.2156 secs
  99% in 28.6775 secs

Details (average, fastest, slowest):
  DNS+dialup:  0.0189 secs, 0.0455 secs, 31.8757 secs
  DNS-lookup:  0.0056 secs, 0.0000 secs, 0.1119 secs
  req write:   0.0020 secs, 0.0000 secs, 0.0695 secs
  resp wait:   7.2017 secs, 0.0453 secs, 31.8354 secs
  resp read:   0.0001 secs, 0.0000 secs, 0.0002 secs

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