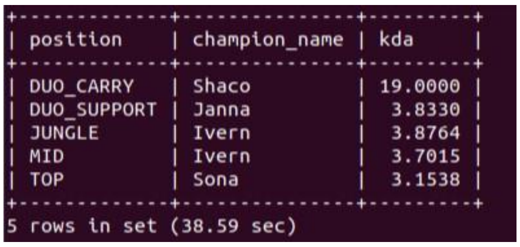
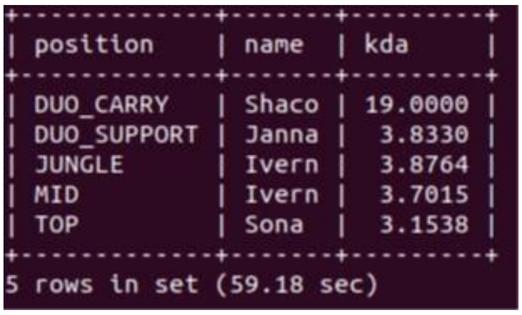
2-1-1



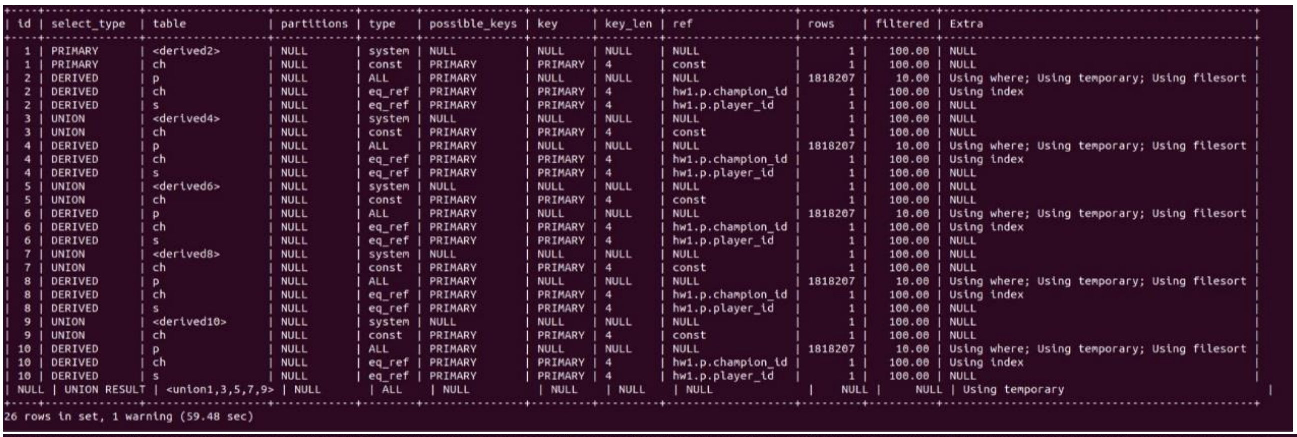
```
+-------------+---------------+---------+
| position    | champion_name | kda     |
+-------------+---------------+---------+
| DUO_CARRY   | Shaco         | 19.0000 |
| DUO_SUPPORT | Janna         |  3.8330 |
| JUNGLE      | Ivern         |  3.8764 |
| MID         | Ivern         |  3.7015 |
| TOP         | Sona          |  3.1538 |
+-------------+---------------+---------+
5 rows in set (38.59 sec)
```



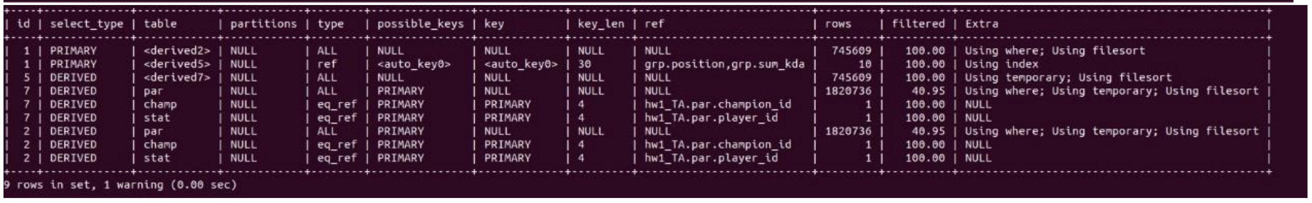
```
+-------------+-------+---------+
| position    | name  | kda     |
+-------------+-------+---------+
| DUO_CARRY   | Shaco | 19.0000 |
| DUO_SUPPORT | Janna |  3.8330 |
| JUNGLE      | Ivern |  3.8764 |
| MID         | Ivern |  3.7015 |
| TOP         | Sona  |  3.1538 |
+-------------+-------+---------+
5 rows in set (59.18 sec)
```

C-7 是我花最久的 sql，大概花了一分鐘左右，而助教的大概只花了 40 秒左右

- 用 explain 來看:



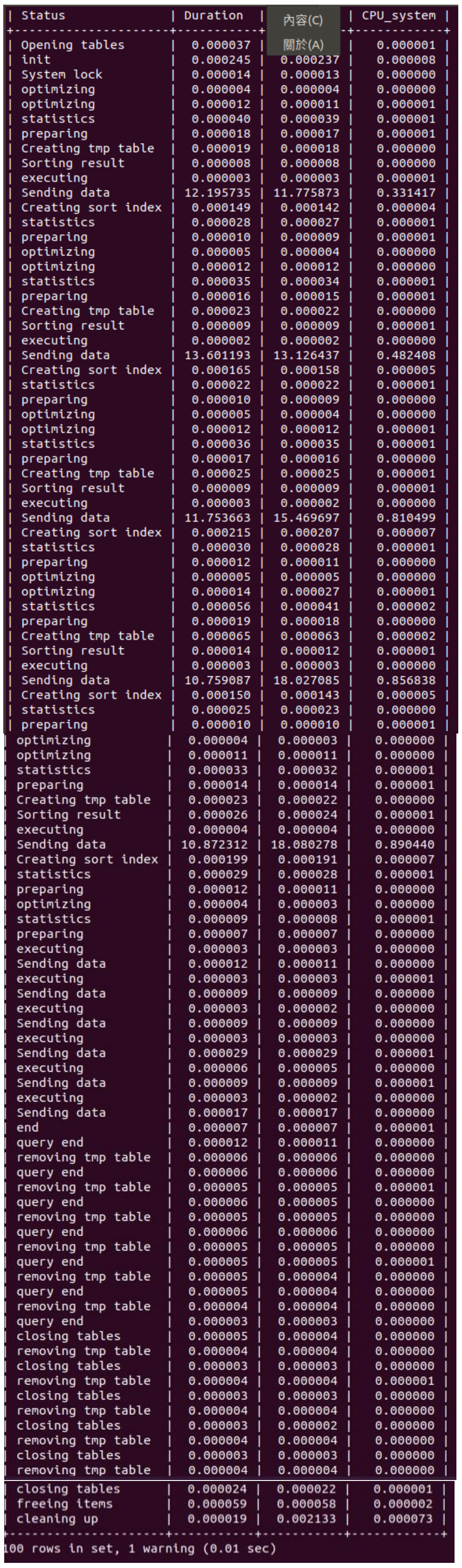
```
+------+--------------+----------------+------------+--------+---------------+---------+---------+--------------------+---------+----------+----------------------------------------------+
| id   | select_type  | table          | partitions | type   | possible_keys | key     | key_len | ref                | rows    | filtered | Extra                                        |
+------+--------------+----------------+------------+--------+---------------+---------+---------+--------------------+---------+----------+----------------------------------------------+
|    1 | PRIMARY      | <derived2>     | NULL       | system | NULL          | NULL    | NULL    | NULL               |       1 |   100.00 | NULL                                         |
|    1 | PRIMARY      | ch             | NULL       | const  | PRIMARY       | PRIMARY | 4       | const              |       1 |   100.00 | NULL                                         |
|    2 | DERIVED      | p              | NULL       | ALL    | PRIMARY       | NULL    | NULL    | NULL               | 1818207 |    10.00 | Using where; Using temporary; Using filesort |
|    2 | DERIVED      | ch             | NULL       | eq_ref | PRIMARY       | PRIMARY | 4       | hw1.p.champion_id  |       1 |   100.00 | Using index                                  |
|    2 | DERIVED      | s              | NULL       | eq_ref | PRIMARY       | PRIMARY | 4       | hw1.p.player_id    |       1 |   100.00 | NULL                                         |
|    3 | UNION        | <derived4>     | NULL       | system | NULL          | NULL    | NULL    | NULL               |       1 |   100.00 | NULL                                         |
|    3 | UNION        | ch             | NULL       | const  | PRIMARY       | PRIMARY | 4       | const              |       1 |   100.00 | NULL                                         |
|    4 | DERIVED      | p              | NULL       | ALL    | PRIMARY       | NULL    | NULL    | NULL               | 1818207 |    10.00 | Using where; Using temporary; Using filesort |
|    4 | DERIVED      | ch             | NULL       | eq_ref | PRIMARY       | PRIMARY | 4       | hw1.p.champion_id  |       1 |   100.00 | Using index                                  |
|    4 | DERIVED      | s              | NULL       | eq_ref | PRIMARY       | PRIMARY | 4       | hw1.p.player_id    |       1 |   100.00 | NULL                                         |
|    5 | UNION        | <derived6>     | NULL       | system | NULL          | NULL    | NULL    | NULL               |       1 |   100.00 | NULL                                         |
|    5 | UNION        | ch             | NULL       | const  | PRIMARY       | PRIMARY | 4       | const              |       1 |   100.00 | NULL                                         |
|    6 | DERIVED      | p              | NULL       | ALL    | PRIMARY       | NULL    | NULL    | NULL               | 1818207 |    10.00 | Using where; Using temporary; Using filesort |
|    6 | DERIVED      | ch             | NULL       | eq_ref | PRIMARY       | PRIMARY | 4       | hw1.p.champion_id  |       1 |   100.00 | Using index                                  |
|    6 | DERIVED      | s              | NULL       | eq_ref | PRIMARY       | PRIMARY | 4       | hw1.p.player_id    |       1 |   100.00 | NULL                                         |
|    7 | UNION        | <derived8>     | NULL       | system | NULL          | NULL    | NULL    | NULL               |       1 |   100.00 | NULL                                         |
|    7 | UNION        | ch             | NULL       | const  | PRIMARY       | PRIMARY | 4       | const              |       1 |   100.00 | NULL                                         |
|    8 | DERIVED      | p              | NULL       | ALL    | PRIMARY       | NULL    | NULL    | NULL               | 1818207 |    10.00 | Using where; Using temporary; Using filesort |
|    8 | DERIVED      | ch             | NULL       | eq_ref | PRIMARY       | PRIMARY | 4       | hw1.p.champion_id  |       1 |   100.00 | Using index                                  |
|    8 | DERIVED      | s              | NULL       | eq_ref | PRIMARY       | PRIMARY | 4       | hw1.p.player_id    |       1 |   100.00 | NULL                                         |
|    9 | UNION        | <derived10>    | NULL       | system | NULL          | NULL    | NULL    | NULL               |       1 |   100.00 | NULL                                         |
|    9 | UNION        | ch             | NULL       | const  | PRIMARY       | PRIMARY | 4       | const              |       1 |   100.00 | NULL                                         |
|   10 | DERIVED      | p              | NULL       | ALL    | PRIMARY       | NULL    | NULL    | NULL               | 1818207 |    10.00 | Using where; Using temporary; Using filesort |
|   10 | DERIVED      | ch             | NULL       | eq_ref | PRIMARY       | PRIMARY | 4       | hw1.p.champion_id  |       1 |   100.00 | Using index                                  |
|   10 | DERIVED      | s              | NULL       | eq_ref | PRIMARY       | PRIMARY | 4       | hw1.p.player_id    |       1 |   100.00 | NULL                                         |
| NULL | UNION RESULT | <union1,3,5,7,9> | NULL     | ALL    | NULL          | NULL    | NULL    | NULL               |    NULL |     NULL | Using temporary                              |
+------+--------------+----------------+------------+--------+---------------+---------+---------+--------------------+---------+----------+----------------------------------------------+
26 rows in set, 1 warning (59.48 sec)
```



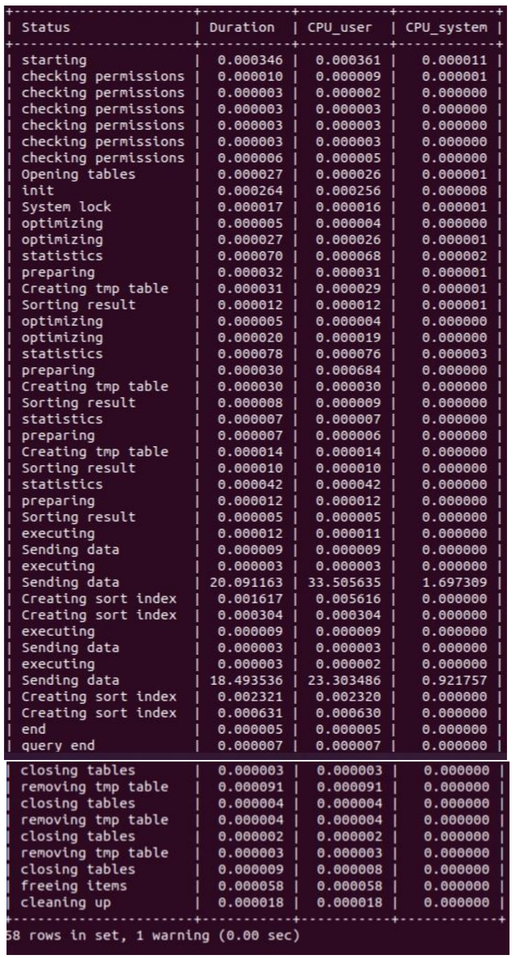
```
+----+-------------+------------+------------+--------+---------------+-------------+---------+----------------------------+---------+----------+----------------------------------------------+
| id | select_type | table      | partitions | type   | possible_keys | key         | key_len | ref                        | rows    | filtered | Extra                                        |
+----+-------------+------------+------------+--------+---------------+-------------+---------+----------------------------+---------+----------+----------------------------------------------+
|  1 | PRIMARY     | <derived2> | NULL       | ALL    | NULL          | NULL        | NULL    | NULL                       |  745609 |   100.00 | Using where; Using filesort                  |
|  1 | PRIMARY     | <derived5> | NULL       | ref    | <auto_key0>   | <auto_key0> | 30      | grp.position,grp.sum_kda   |      10 |   100.00 | Using index                                  |
|  5 | DERIVED     | <derived7> | NULL       | ALL    | NULL          | NULL        | NULL    | NULL                       |  745609 |   100.00 | Using temporary; Using filesort              |
|  7 | DERIVED     | par        | NULL       | ALL    | PRIMARY       | NULL        | NULL    | NULL                       | 1820736 |    40.95 | Using where; Using temporary; Using filesort |
|  7 | DERIVED     | champ      | NULL       | eq_ref | PRIMARY       | PRIMARY     | 4       | hw1_TA.par.champion_id     |       1 |   100.00 | NULL                                         |
|  7 | DERIVED     | stat       | NULL       | eq_ref | PRIMARY       | PRIMARY     | 4       | hw1_TA.par.player_id       |       1 |   100.00 | NULL                                         |
|  2 | DERIVED     | par        | NULL       | ALL    | PRIMARY       | NULL        | NULL    | NULL                       | 1820736 |    40.95 | Using where; Using temporary; Using filesort |
|  2 | DERIVED     | champ      | NULL       | eq_ref | PRIMARY       | PRIMARY     | 4       | hw1_TA.par.champion_id     |       1 |   100.00 | NULL                                         |
|  2 | DERIVED     | stat       | NULL       | eq_ref | PRIMARY       | PRIMARY     | 4       | hw1_TA.par.player_id       |       1 |   100.00 | NULL                                         |
+----+-------------+------------+------------+--------+---------------+-------------+---------+----------------------------+---------+----------+----------------------------------------------+
9 rows in set, 1 warning (0.00 sec)
```

發現我的行數比助教的多出很多，因為我是分別將 5 個 position 算好之後再 union，所以需要重複做五次。從 explain 的 type 中也可以看到我的 ALL 的數量更多，ALL 是針對每一筆記錄進行完全掃描為最壞的情況。type：最優至最差的類型為 const、eq_reg、ref、range、ALL。因此在執行的速度上助教寫的 sql 會比較快。

• 以 profile 來看 ：



```
| Status               | Duration  |           | CPU_system |
+----------------------+-----------+           +------------+
| Opening tables       |  0.000037 |           |   0.000001 |
| init                 |  0.000245 |  0.000237 |   0.000008 |
| System lock          |  0.000014 |  0.000013 |   0.000000 |
| optimizing           |  0.000004 |  0.000004 |   0.000000 |
| optimizing           |  0.000012 |  0.000011 |   0.000001 |
| statistics           |  0.000040 |  0.000039 |   0.000001 |
| preparing            |  0.000018 |  0.000017 |   0.000001 |
| Creating tmp table   |  0.000019 |  0.000018 |   0.000000 |
| Sorting result       |  0.000008 |  0.000008 |   0.000000 |
| executing            |  0.000003 |  0.000003 |   0.000001 |
| Sending data         | 12.195735 | 11.775873 |   0.331417 |
| Creating sort index  |  0.000149 |  0.000142 |   0.000004 |
| statistics           |  0.000028 |  0.000027 |   0.000001 |
| preparing            |  0.000010 |  0.000009 |   0.000001 |
| optimizing           |  0.000005 |  0.000004 |   0.000000 |
| optimizing           |  0.000012 |  0.000012 |   0.000000 |
| statistics           |  0.000035 |  0.000034 |   0.000001 |
| preparing            |  0.000016 |  0.000015 |   0.000001 |
| Creating tmp table   |  0.000023 |  0.000022 |   0.000000 |
| Sorting result       |  0.000009 |  0.000009 |   0.000001 |
| executing            |  0.000002 |  0.000002 |   0.000000 |
| Sending data         | 13.601193 | 13.126437 |   0.482408 |
| Creating sort index  |  0.000165 |  0.000158 |   0.000005 |
| statistics           |  0.000022 |  0.000022 |   0.000001 |
| preparing            |  0.000010 |  0.000009 |   0.000000 |
| optimizing           |  0.000005 |  0.000004 |   0.000000 |
| optimizing           |  0.000012 |  0.000012 |   0.000001 |
| statistics           |  0.000036 |  0.000035 |   0.000001 |
| preparing            |  0.000017 |  0.000016 |   0.000000 |
| Creating tmp table   |  0.000025 |  0.000025 |   0.000001 |
| Sorting result       |  0.000009 |  0.000009 |   0.000001 |
| executing            |  0.000003 |  0.000002 |   0.000000 |
| Sending data         | 11.753663 | 15.469697 |   0.810499 |
| Creating sort index  |  0.000215 |  0.000207 |   0.000007 |
| statistics           |  0.000030 |  0.000028 |   0.000001 |
| preparing            |  0.000012 |  0.000011 |   0.000000 |
| optimizing           |  0.000005 |  0.000005 |   0.000000 |
| optimizing           |  0.000014 |  0.000027 |   0.000001 |
| statistics           |  0.000056 |  0.000041 |   0.000002 |
| preparing            |  0.000019 |  0.000018 |   0.000000 |
| Creating tmp table   |  0.000065 |  0.000063 |   0.000002 |
| Sorting result       |  0.000014 |  0.000012 |   0.000001 |
| executing            |  0.000003 |  0.000003 |   0.000000 |
| Sending data         | 10.759087 | 18.027085 |   0.856838 |
| Creating sort index  |  0.000150 |  0.000143 |   0.000005 |
| statistics           |  0.000025 |  0.000023 |   0.000000 |
| preparing            |  0.000010 |  0.000010 |   0.000001 |
| optimizing           |  0.000004 |  0.000003 |   0.000000 |
| optimizing           |  0.000011 |  0.000011 |   0.000000 |
| statistics           |  0.000033 |  0.000032 |   0.000001 |
| preparing            |  0.000014 |  0.000014 |   0.000001 |
| Creating tmp table   |  0.000023 |  0.000022 |   0.000000 |
| Sorting result       |  0.000026 |  0.000024 |   0.000001 |
| executing            |  0.000004 |  0.000004 |   0.000000 |
| Sending data         | 10.872312 | 18.080278 |   0.890440 |
| Creating sort index  |  0.000199 |  0.000191 |   0.000007 |
| statistics           |  0.000029 |  0.000028 |   0.000001 |
| preparing            |  0.000012 |  0.000011 |   0.000000 |
| optimizing           |  0.000004 |  0.000003 |   0.000000 |
| statistics           |  0.000009 |  0.000008 |   0.000001 |
| preparing            |  0.000007 |  0.000007 |   0.000000 |
| executing            |  0.000003 |  0.000003 |   0.000000 |
| Sending data         |  0.000012 |  0.000011 |   0.000000 |
| executing            |  0.000003 |  0.000003 |   0.000001 |
| Sending data         |  0.000009 |  0.000009 |   0.000000 |
| executing            |  0.000003 |  0.000002 |   0.000000 |
| Sending data         |  0.000009 |  0.000009 |   0.000000 |
| executing            |  0.000003 |  0.000003 |   0.000000 |
| Sending data         |  0.000029 |  0.000029 |   0.000001 |
| executing            |  0.000006 |  0.000005 |   0.000000 |
| Sending data         |  0.000009 |  0.000009 |   0.000001 |
| executing            |  0.000003 |  0.000002 |   0.000000 |
| Sending data         |  0.000017 |  0.000017 |   0.000000 |
| end                  |  0.000007 |  0.000007 |   0.000001 |
| query end            |  0.000012 |  0.000011 |   0.000000 |
| removing tmp table   |  0.000006 |  0.000006 |   0.000000 |
| query end            |  0.000006 |  0.000006 |   0.000000 |
| removing tmp table   |  0.000005 |  0.000005 |   0.000001 |
| query end            |  0.000006 |  0.000005 |   0.000000 |
| removing tmp table   |  0.000005 |  0.000005 |   0.000000 |
| query end            |  0.000006 |  0.000006 |   0.000000 |
| removing tmp table   |  0.000005 |  0.000005 |   0.000000 |
| query end            |  0.000005 |  0.000005 |   0.000001 |
| removing tmp table   |  0.000005 |  0.000004 |   0.000000 |
| query end            |  0.000005 |  0.000004 |   0.000000 |
| removing tmp table   |  0.000004 |  0.000004 |   0.000000 |
| query end            |  0.000003 |  0.000003 |   0.000000 |
| closing tables       |  0.000005 |  0.000004 |   0.000000 |
| removing tmp table   |  0.000004 |  0.000004 |   0.000000 |
| closing tables       |  0.000003 |  0.000003 |   0.000000 |
| removing tmp table   |  0.000004 |  0.000004 |   0.000001 |
| closing tables       |  0.000003 |  0.000003 |   0.000000 |
| removing tmp table   |  0.000004 |  0.000004 |   0.000000 |
| closing tables       |  0.000003 |  0.000002 |   0.000000 |
| removing tmp table   |  0.000004 |  0.000004 |   0.000000 |
| closing tables       |  0.000003 |  0.000003 |   0.000000 |
| removing tmp table   |  0.000004 |  0.000004 |   0.000000 |
| closing tables       |  0.000024 |  0.000022 |   0.000001 |
| freeing items        |  0.000059 |  0.000058 |   0.000002 |
| cleaning up          |  0.000019 |  0.002133 |   0.000073 |
+----------------------+-----------+-----------+------------+
100 rows in set, 1 warning (0.01 sec)
```

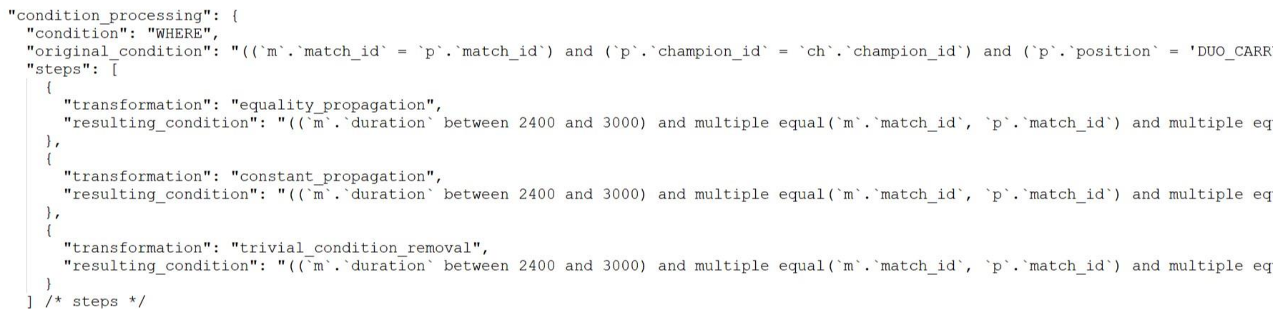


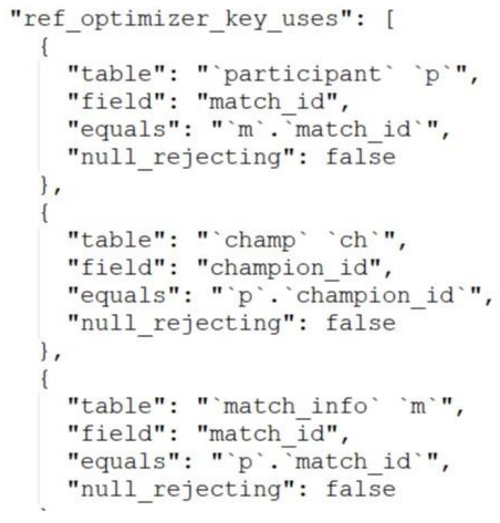
```
+----------------------+-----------+-----------+------------+
| Status               | Duration  | CPU_user  | CPU_system |
+----------------------+-----------+-----------+------------+
| starting             |  0.000346 |  0.000361 |   0.000011 |
| checking permissions |  0.000010 |  0.000009 |   0.000001 |
| checking permissions |  0.000003 |  0.000002 |   0.000000 |
| checking permissions |  0.000003 |  0.000003 |   0.000000 |
| checking permissions |  0.000003 |  0.000003 |   0.000000 |
| checking permissions |  0.000003 |  0.000003 |   0.000000 |
| checking permissions |  0.000006 |  0.000005 |   0.000000 |
| Opening tables       |  0.000027 |  0.000026 |   0.000001 |
| init                 |  0.000264 |  0.000256 |   0.000008 |
| System lock          |  0.000017 |  0.000016 |   0.000001 |
| optimizing           |  0.000005 |  0.000004 |   0.000000 |
| optimizing           |  0.000027 |  0.000026 |   0.000001 |
| statistics           |  0.000070 |  0.000068 |   0.000002 |
| preparing            |  0.000032 |  0.000031 |   0.000001 |
| Creating tmp table   |  0.000031 |  0.000029 |   0.000001 |
| Sorting result       |  0.000012 |  0.000012 |   0.000001 |
| optimizing           |  0.000005 |  0.000004 |   0.000000 |
| optimizing           |  0.000020 |  0.000019 |   0.000000 |
| statistics           |  0.000078 |  0.000076 |   0.000003 |
| preparing            |  0.000030 |  0.000684 |   0.000000 |
| Creating tmp table   |  0.000030 |  0.000030 |   0.000000 |
| Sorting result       |  0.000008 |  0.000009 |   0.000000 |
| statistics           |  0.000007 |  0.000007 |   0.000000 |
| preparing            |  0.000007 |  0.000006 |   0.000000 |
| Creating tmp table   |  0.000014 |  0.000014 |   0.000000 |
| Sorting result       |  0.000010 |  0.000010 |   0.000000 |
| statistics           |  0.000042 |  0.000042 |   0.000000 |
| preparing            |  0.000012 |  0.000012 |   0.000000 |
| Sorting result       |  0.000005 |  0.000005 |   0.000000 |
| executing            |  0.000012 |  0.000011 |   0.000000 |
| Sending data         |  0.000009 |  0.000009 |   0.000000 |
| executing            |  0.000003 |  0.000003 |   0.000000 |
| Sending data         | 20.091163 | 33.505635 |   1.697309 |
| Creating sort index  |  0.001617 |  0.005616 |   0.000000 |
| Creating sort index  |  0.000304 |  0.000304 |   0.000000 |
| executing            |  0.000009 |  0.000009 |   0.000000 |
| Sending data         |  0.000003 |  0.000003 |   0.000000 |
| executing            |  0.000003 |  0.000002 |   0.000000 |
| Sending data         | 18.493536 | 23.303486 |   0.921757 |
| Creating sort index  |  0.002321 |  0.002320 |   0.000000 |
| Creating sort index  |  0.000631 |  0.000630 |   0.000000 |
| end                  |  0.000005 |  0.000005 |   0.000000 |
| query end            |  0.000007 |  0.000007 |   0.000000 |
| closing tables       |  0.000003 |  0.000003 |   0.000000 |
| removing tmp table   |  0.000091 |  0.000091 |   0.000000 |
| closing tables       |  0.000004 |  0.000004 |   0.000000 |
| removing tmp table   |  0.000004 |  0.000004 |   0.000000 |
| closing tables       |  0.000002 |  0.000002 |   0.000000 |
| removing tmp table   |  0.000003 |  0.000003 |   0.000000 |
| closing tables       |  0.000009 |  0.000008 |   0.000000 |
| freeing items        |  0.000058 |  0.000058 |   0.000000 |
| cleaning up          |  0.000018 |  0.000018 |   0.000000 |
+----------------------+-----------+-----------+------------+
58 rows in set, 1 warning (0.00 sec)
```

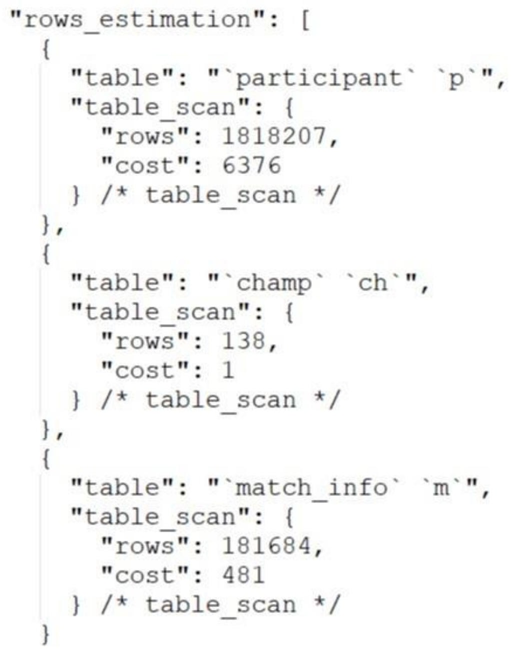
用 profile 來看也可以看出我寫的 sql 花的指令比較多，需要用掉更多的時間

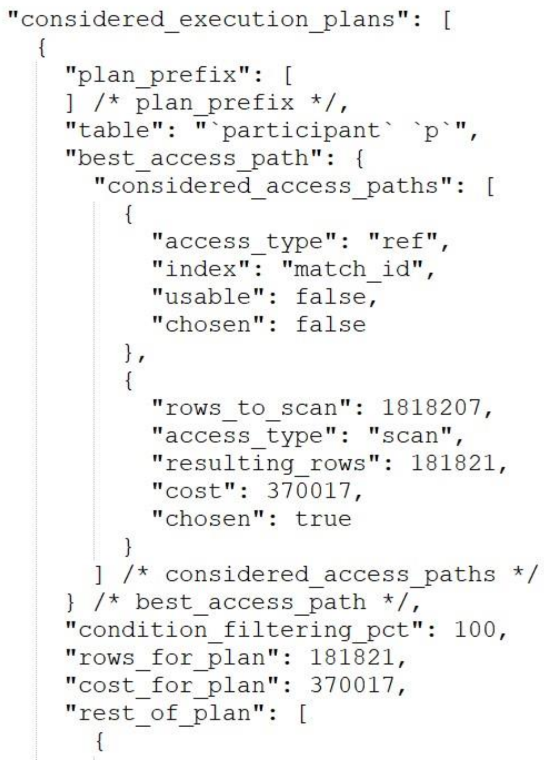
2-1-2

用 mysql trace optimizer trace 出來的檔案分為 join_preparation、join_optimization、join_execution 三個部分，其中主要的是 join_optimization

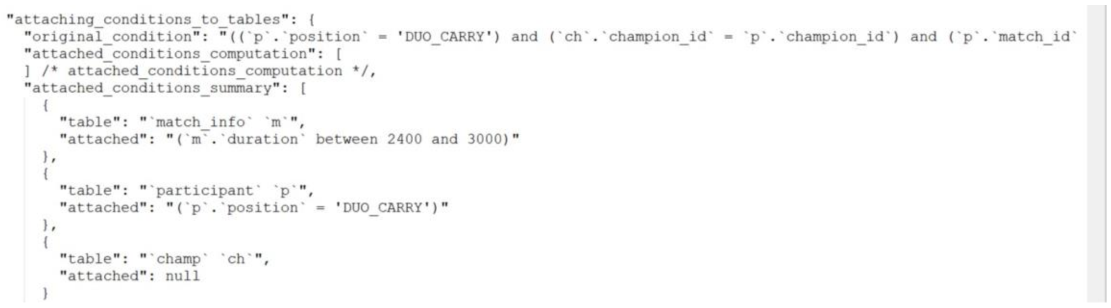

```
"condition_processing": {
  "condition": "WHERE",
  "original_condition": "((`m`.`match_id` = `p`.`match_id`) and (`p`.`champion_id` = `ch`.`champion_id`) and (`p`.`position` = 'DUO_CARR
  "steps": [
    {
      "transformation": "equality_propagation",
      "resulting_condition": "((`m`.`duration` between 2400 and 3000) and multiple equal(`m`.`match_id`, `p`.`match_id`) and multiple eq
    },
    {
      "transformation": "constant_propagation",
      "resulting_condition": "((`m`.`duration` between 2400 and 3000) and multiple equal(`m`.`match_id`, `p`.`match_id`) and multiple eq
    },
    {
      "transformation": "trivial_condition_removal",
      "resulting_condition": "((`m`.`duration` between 2400 and 3000) and multiple equal(`m`.`match_id`, `p`.`match_id`) and multiple eq
    }
  ] /* steps */
```


```
"ref_optimizer_key_uses": [
  {
    "table": "`participant` `p`",
    "field": "match_id",
    "equals": "`m`.`match_id`",
    "null_rejecting": false
  },
  {
    "table": "`champ` `ch`",
    "field": "champion_id",
    "equals": "`p`.`champion_id`",
    "null_rejecting": false
  },
  {
    "table": "`match_info` `m`",
    "field": "match_id",
    "equals": "`p`.`match_id`",
    "null_rejecting": false
```

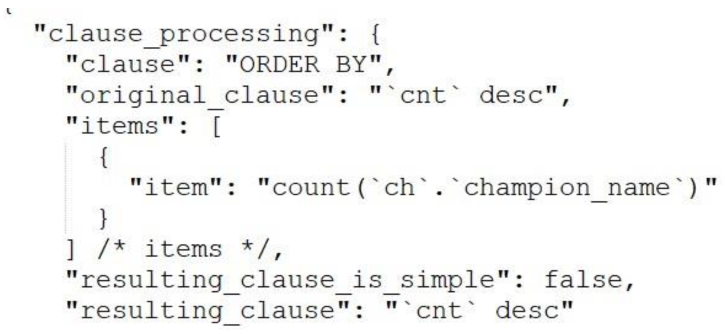

```
"rows_estimation": [
  {
    "table": "`participant` `p`",
    "table_scan": {
      "rows": 1818207,
      "cost": 6376
    } /* table_scan */
  },
  {
    "table": "`champ` `ch`",
    "table_scan": {
      "rows": 138,
      "cost": 1
    } /* table_scan */
  },
  {
    "table": "`match_info` `m`",
    "table_scan": {
      "rows": 181684,
      "cost": 481
    } /* table_scan */
  }
```



```
"considered_execution_plans": [
  {
    "plan_prefix": [
    ] /* plan_prefix */,
    "table": "`participant` `p`",
    "best_access_path": {
      "considered_access_paths": [
        {
          "access_type": "ref",
          "index": "match_id",
          "usable": false,
          "chosen": false
        },
        {
          "rows_to_scan": 1818207,
          "access_type": "scan",
          "resulting_rows": 181821,
          "cost": 370017,
          "chosen": true
        }
      ] /* considered_access_paths */
    } /* best_access_path */,
    "condition_filtering_pct": 100,
    "rows_for_plan": 181821,
    "cost_for_plan": 370017,
    "rest_of_plan": [
      {
```



```
"attaching_conditions_to_tables": {
  "original_condition": "((`p`.`position` = 'DUO_CARRY') and (`ch`.`champion_id` = `p`.`champion_id`) and (`p`.`match_id`
  "attached_conditions_computation": [
  ] /* attached_conditions_computation */,
  "attached_conditions_summary": [
    {
      "table": "`match_info` `m`",
      "attached": "(`m`.`duration` between 2400 and 3000)"
    },
    {
      "table": "`participant` `p`",
      "attached": "(`p`.`position` = 'DUO_CARRY')"
    },
    {
      "table": "`champ` `ch`",
      "attached": null
    }
```



```
"clause_processing": {
  "clause": "ORDER BY",
  "original_clause": "`cnt` desc",
  "items": [
    {
      "item": "count(`ch`.`champion_name`)"
    }
  ] /* items */,
  "resulting_clause_is_simple": false,
  "resulting_clause": "`cnt` desc"
```

對於每一個 sql，一開始是 condition_processing 進行 where 的條件處理，再來是 ref_optimizer_key_uses、rows_estimation，去看要 scan 多少 rows 以及 cost，接著就是 considered_excution_plans 將 table 連接起來，acess type 也是有 const、eq_reg、ref、range、ALL，越後面的效能越差，接著是 attaching_conditions_to_tables 及最後的 clause_processing 處理 group by 及 order by。

因為我 hw1 的 C-6 是分別將那 5 個 position 中出現最多次的英雄個別算出最後

在全部 union，因此 trace 完的結果有 3500 多行，因為每個 position 都重複做同樣的事情但我沒有用 group by 寫，所以需要跑很多次，也造成 type 中的 ALL 出現更多次。而助教的 sql 不是將 5 個 position 做 union 因此 select 的數量較少，也不需要一直重複做同樣的事情，就不需要重複掃描很多次，因此執行的時間較快。

2-2-1

◆working flow:

1. 將需要的 thread number 從 argv 中讀出
2. 讀出 variable 的數量及值，將值存入 vector 中
3. 讀出每個 equartion，parse 後將其裝入 struct 中
4. 將每個 job 裝入 queue 中型成 job list，trigger a “job semaphore”
5. create the threads
6. 某個 thread 會接到這個 job，之後 implement 2PL，job 執行完後 trigger a “finished semaphore”，重複做直到所有的 job 都結束
7. 藉由 thread_join 在 main 中等 thread 結束，之後將結果寫入 output file

◆ code&detail:

```
#include <iostream>
#include <vector>
#include <string>
#include <pthread.h>
#include <unistd.h>
#include <cstdlib>
#include <semaphore.h>
#include <fstream>
#include <queue>
#include <ctime>
using namespace std;

vector<int> num;
vector<vector<string>> number(100);
vector<vector<string>> operation(100);
sem_t semaphore, semaphore2;
vector<pthread_mutex_t> locker;
pthread_mutex_t job_lock;
clock_t Begin, End;
double duration;
```

```
struct mystruct
{
    vector<string> number;
    vector<string> operation;
    vector<int> var;
};
queue<mystruct> q;
void *cal(void *p);
```

一開始先，宣告一些 variable

- num： 一開始 cin 進來的 variable 的值
- number： 每個 equation 刪除完 ’=’、’+’、’-‘後剩下的 string
- operation： 每個 equation 中的 operand
- semaphore： 判斷該 job 是否完成
- semaphore2： 判斷是否有 100 個 job
- locker： 每個 variable 都開一個 mutex
- job_lock： 確保該 job 只有一個 thread 可以拿到
- Begin： 開始計時
- End： 結束計時
- Duration： 經過的時間
- mystruct：
  - number： 該 job 刪除完 ’=’、’+’、’-‘後剩下的 string
  - Operation： 該 job 中的 operand
  - var： 該 job 中需要被 read/write 的 variable
- q： 進到 function 內每個 job 所需的 vector
- void* cal (void* p) : function 宣告

```
int main(int argc, char *argv[])
{
    Begin = clock();
    int thread_num = atoi(argv[1]);
    string output_name = argv[2];
    int N;
    cin >> N;
    num.resize(N);
    locker.resize(N);

    for (int i = 0; i < N; i++)
    {
        cin >> num[i];
        pthread_mutex_init(&locker[i], 0);
    }
    string temp;
    vector<string> equation;
    vector<vector<string>> sequence(100);
    vector<vector<int>> var(100);
    sem_init(&semaphore, 0, 0);
    sem_init(&semaphore2, 0, 0);

    getline(cin, temp);
    while (getline(cin, temp))
        equation.push_back(temp);
```

- Begin： 開始計時
- thread_num： 所需的 thread 數量
- output_name : output file 的名字
- cin>>N： 讀進 variable 的數量
- num 與 locker 都有 N 個，所以將其 resize
- for 迴圈 ：
    - –讀進 variable 的值
    - –initialize locker
- getline(cin,temp)： 因為會多讀到一行空白的值，因此先將其讀掉
- while 迴圈 ： 將每一行運算是以 string 的方式讀進來，存到 equation 中

```
int front = 0, back;
    for (int i = 0; i < equation.size(); i++)
    {

        front = 0;
        for (int j = 0; j < equation[i].size(); j++)
        {
            if (equation[i][j] == ' ')
            {
                back = j;
                string s;
                for (int k = front; k < back; k++)
                    s.push_back(equation[i][k]);
                sequence[i].push_back(s);
                front = back + 1;
            }
        }
        back = equation[i].size();
        string s;
        for (int k = front; k < back; k++)
            s.push_back(equation[i][k]);
        sequence[i].push_back(s);
    }
```

- 藉由空白將每個 equation 中的 string 分出來存到 sequence 中
  - front 為 string 前面的 index，back 為 string 後面的 index
  - for 迴圈跑完後無法將最後一個字串分出來，因此在迴圈外多分一次

```
for (int i = 0; i < 100; i++)
    {
        for (int j = 0; j < sequence[i].size(); j++)
        {
            if (sequence[i][j] == "+" || sequence[i][j] == "-")
                operation[i].push_back(sequence[i][j]);
            else if (sequence[i][j] != "=")
            {
                number[i].push_back(sequence[i][j]);
                if (sequence[i][j][0] == '$')
                {
                    int t = stoi(sequence[i][j].erase(0, 1));
                    bool same = false;
                    for (int k = 0; k < var[i].size(); k++)
                    {
                        if (t == var[i][k])
                        {
                            same = true;
                            break;
                        }
                    }
                    if (same == false)
                        var[i].push_back(t);
                }
```

- 將 sequrnce 的 + ,- 存到 operation，將 variable 及 constant 存到 number 中，遇到$時代表是 variable 再另外存到 var 中，如果前面已經存過了就不存

```
struct mystruct data[100];
    for (int i = 0; i < 100; i++)
    {
        data[i].number = number[i];
        data[i].operation = operation[i];
        data[i].var = var[i];
        q.push(data[i]);
        sem_post(&semaphore2);
    }

    pthread_t t[thread_num];
    for (int i = 0; i < thread_num; i++)
        pthread_create(&t[i], NULL, cal, NULL);

    for (int i = 0; i < 100; i++)
        sem_wait(&semaphore);

    for (int i = 0; i < thread_num; i++)
        pthread_join(t[i], NULL);

    ofstream file(output_name);
    if (file.is_open())
    {
        for (int i = 0; i < num.size(); i++)
            file << '$' << i << " = " << num[i] << endl;
    }

    End = clock(); //結束計時
    duration = double(End - Begin) / CLOCKS_PER_SEC;
    cout << "Thread number : " << thread_num << endl;
    cout << "Time :" << duration << " s" << endl;
    return 0;
```

- 1st for 迴圈 ： 將 number、operation、var 包成一個 structure 再 push 進 queue 中，也 post semaphore2

- 2nd for 迴圈 ： 建立子執行序
- 3rd for 迴圈 ： 確保子執行序有執行 100 次
- 4th for 迴圈 ： 等子執行序全部執行完後將其 join
- 都算完後將 num 的值寫進檔案中
- End： 結束計時
- duration： 經過了多少時間
- cout 出 thread number 及整個程式經過了多少時間

```
void *cal(void *p)
{
    while (q.size() != 0)
    {
        if (sem_trywait(&semaphore2)==0)
        {
            pthread_mutex_lock(&job_lock);
            struct mystruct my_data;
            my_data = q.front();
            q.pop();
            for (int i = 0; i < my_data.var.size(); i++)
                pthread_mutex_lock(&locker[my_data.var[i]]);
            pthread_mutex_unlock(&job_lock);

            vector<int> input;
            input = num;
            for (int i = 1; i < my_data.var.size(); i++)
                pthread_mutex_unlock(&locker[my_data.var[i]]);
           int write_target = my_data.var[0];
```

- 當 queue 不是 empty 時代表 100 個 equation 還沒執行完，要繼續執行
- sem_trywait(&semaphore2)==0： 代表有減成功，100 個 equation 尚未執行完，因為是許多 thread 同時執行，所以可能在最後的 data 尚未被 pop 時又有新的 thread 進入 while，但其實 100 個 equation 已經做完了
- pthread_mutex_lock(&job_lock)： 一開始先將此 job lock 住，避免有兩個 thread 接到同一個 job
- 將 queue 的第一個 data 存到 my_data 中再將其 pop 掉
- 1st for 迴圈 ： 將此 job 中會用到的 variable 都 lock。為 growing phase
- 將 variable lock 後 unlock 該 job，其他 thread 就可以接其他的 job
- 把目前 variable 的值存進 input 中，後面運算時就用 input 的值，因此就可以 unlock 該 job 的 read lock

- 2nd for 迴圈 ：unlock 該 job 的 read lock，因為 my_data.var 中存的是該 job 中會用到的 variable，且每個 job 的最左邊為要 write 的 variable，會存在 my_data.var[0]，因此不會 unlock 到 write variable。為 shrinking phase

```
            vector<string> read_string;
            vector<int> read_data;

            int j = 0;
            for (int i = 1; i < my_data.number.size(); i++)
            {
                if (my_data.number[i][0] == '$')
                {
                    read_string.push_back(my_data.number[i].erase(0, 1));
                    int read_target = stoi(read_string[j]);
                    read_data.push_back(input[read_target]);
                    j++;
                }
                else
                    read_data.push_back(stoi(my_data.number[i]));
            }
```

- 將該 job 所需的變數的值讀出及將常數轉成 int，存進 read_data 中

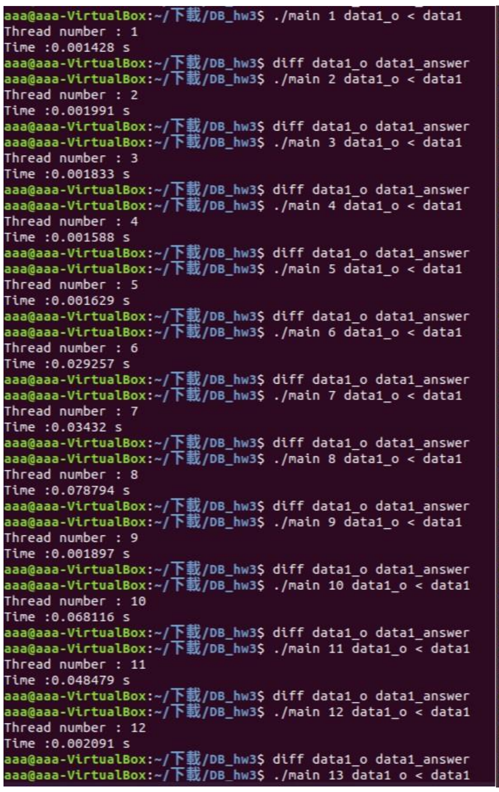
```
            int sum = read_data[0];
            for (int i = 0; i < my_data.operation.size(); i++)
            {
                if (my_data.operation[i] == "+")
                    sum += read_data[i + 1];
                else if (my_data.operation[i] == "-")
                    sum -= read_data[i + 1];
            }
            num[write_target] = sum;
            pthread_mutex_unlock(&locker[write_target]);
            sem_post(&semaphore);


        }
            }
    pthread_exit(NULL);
}
```

- 將運算後的值存成存進 sum 後再將 write 進原本的 num 中
- pthread_mutex_unlock(&locker[write_target]) : unlock write variable 因為已經 Write 完了。為 shrinking phase
- sem_post(&semaphore) : 代表此 job 做完了

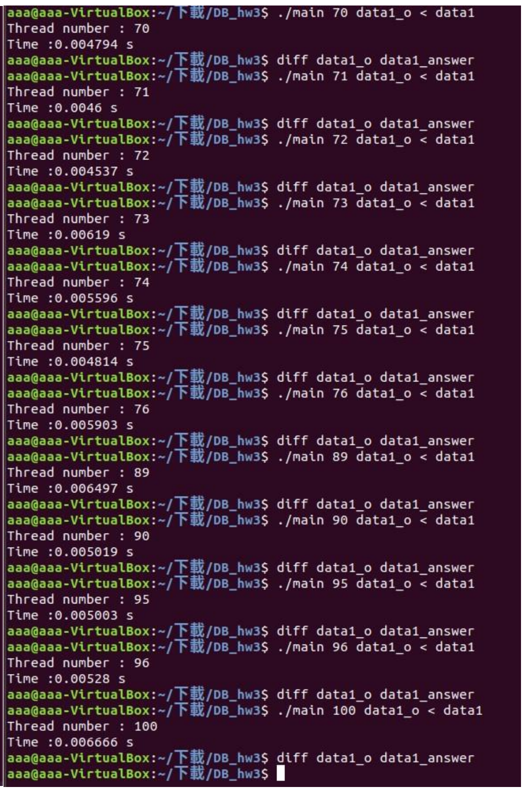
2-2-2

◆同一種 type 的執行時間並沒有差很多，一次很多個 thread 跟一次只有很少個的 thread 也只有差個零點幾秒，可能是因為即使有很多 thread 但有些
variable
已經被 lock，需要等前面的做完才能做，也可能是因為我讀 data、parsing 及
◆寫檔就已經佔了大部分的的時間，因此看起來執行時間都差不多
不同種 type 的時間就相差的比較大，因為我是計算整個 program 的時間，variable 數量越多及 equation 越多都會造成執行時間越久，大致上 type2 比 type1 久，type3 又比 type2 久

˙type 1 :

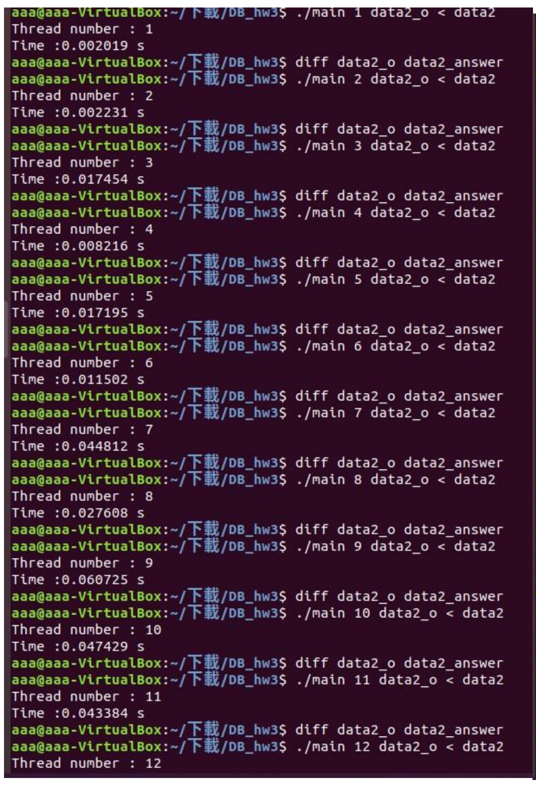


```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 1 data1_o < data1
Thread number : 1
Time :0.001428 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 2 data1_o < data1
Thread number : 2
Time :0.001991 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 3 data1_o < data1
Thread number : 3
Time :0.001833 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 4 data1_o < data1
Thread number : 4
Time :0.001588 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 5 data1_o < data1
Thread number : 5
Time :0.001629 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 6 data1_o < data1
Thread number : 6
Time :0.029257 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 7 data1_o < data1
Thread number : 7
Time :0.03432 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 8 data1_o < data1
Thread number : 8
Time :0.078794 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 9 data1_o < data1
Thread number : 9
Time :0.001897 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 10 data1_o < data1
Thread number : 10
Time :0.068116 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 11 data1_o < data1
Thread number : 11
Time :0.048479 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 12 data1_o < data1
Thread number : 12
Time :0.002091 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 13 data1 o < data1
```

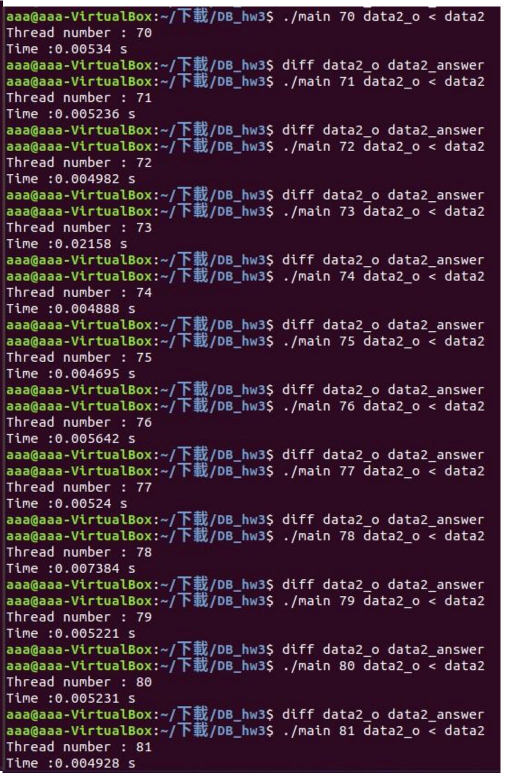


```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 70 data1_o < data1
Thread number : 70
Time :0.004794 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 71 data1_o < data1
Thread number : 71
Time :0.0046 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 72 data1_o < data1
Thread number : 72
Time :0.004537 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 73 data1_o < data1
Thread number : 73
Time :0.00619 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 74 data1_o < data1
Thread number : 74
Time :0.005596 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 75 data1_o < data1
Thread number : 75
Time :0.004814 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 76 data1_o < data1
Thread number : 76
Time :0.005903 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 89 data1_o < data1
Thread number : 89
Time :0.006497 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 90 data1_o < data1
Thread number : 90
Time :0.005019 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 95 data1_o < data1
Thread number : 95
Time :0.005003 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 96 data1_o < data1
Thread number : 96
Time :0.00528 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 100 data1_o < data1
Thread number : 100
Time :0.006666 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data1_o data1_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$
```

˙type 2 :

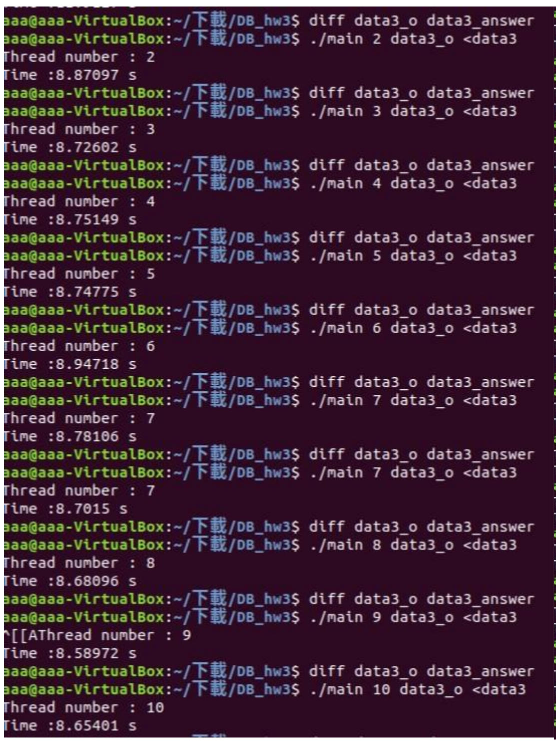


```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 1 data2_o < data2
Thread number : 1
Time :0.002019 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 2 data2_o < data2
Thread number : 2
Time :0.002231 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 3 data2_o < data2
Thread number : 3
Time :0.017454 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 4 data2_o < data2
Thread number : 4
Time :0.008216 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 5 data2_o < data2
Thread number : 5
Time :0.017195 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 6 data2_o < data2
Thread number : 6
Time :0.011502 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 7 data2_o < data2
Thread number : 7
Time :0.044812 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 8 data2_o < data2
Thread number : 8
Time :0.027608 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 9 data2_o < data2
Thread number : 9
Time :0.060725 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 10 data2_o < data2
Thread number : 10
Time :0.047429 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 11 data2_o < data2
Thread number : 11
Time :0.043384 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 12 data2_o < data2
Thread number : 12
```

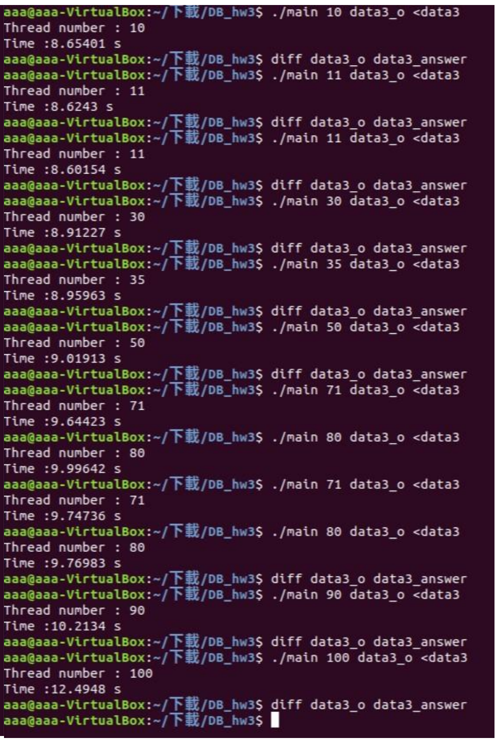


```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 70 data2_o < data2
Thread number : 70
Time :0.00534 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 71 data2_o < data2
Thread number : 71
Time :0.005236 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 72 data2_o < data2
Thread number : 72
Time :0.004982 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 73 data2_o < data2
Thread number : 73
Time :0.02158 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 74 data2_o < data2
Thread number : 74
Time :0.004888 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 75 data2_o < data2
Thread number : 75
Time :0.004695 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 76 data2_o < data2
Thread number : 76
Time :0.005642 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 77 data2_o < data2
Thread number : 77
Time :0.00524 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 78 data2_o < data2
Thread number : 78
Time :0.007384 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 79 data2_o < data2
Thread number : 79
Time :0.005221 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 80 data2_o < data2
Thread number : 80
Time :0.005231 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 81 data2_o < data2
Thread number : 81
Time :0.004928 s
```

˙type 3 :



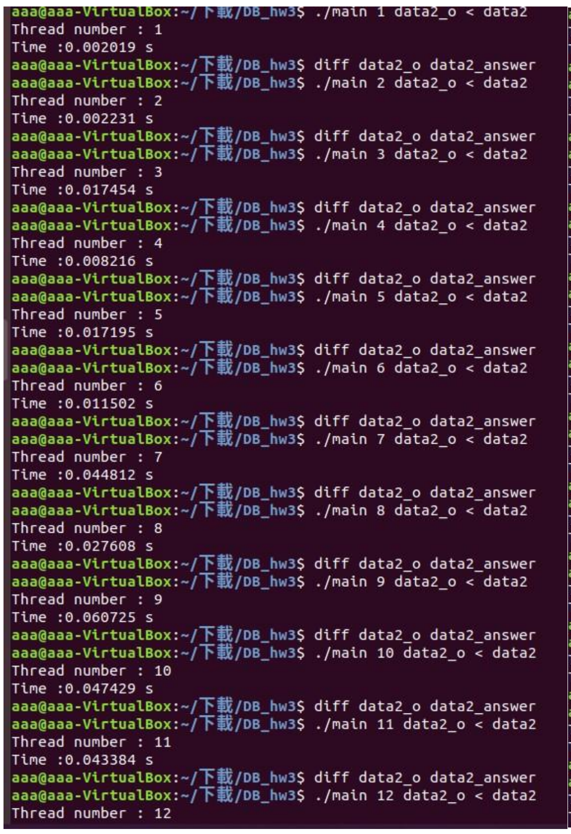
```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 2 data3_o <data3
Thread number : 2
Time :8.87097 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 3 data3_o <data3
Thread number : 3
Time :8.72602 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 4 data3_o <data3
Thread number : 4
Time :8.75149 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 5 data3_o <data3
Thread number : 5
Time :8.74775 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 6 data3_o <data3
Thread number : 6
Time :8.94718 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 7 data3_o <data3
Thread number : 7
Time :8.78106 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 7 data3_o <data3
Thread number : 7
Time :8.7015 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 8 data3_o <data3
Thread number : 8
Time :8.68096 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 9 data3_o <data3
^[[AThread number : 9
Time :8.58972 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 10 data3_o <data3
Thread number : 10
Time :8.65401 s
```



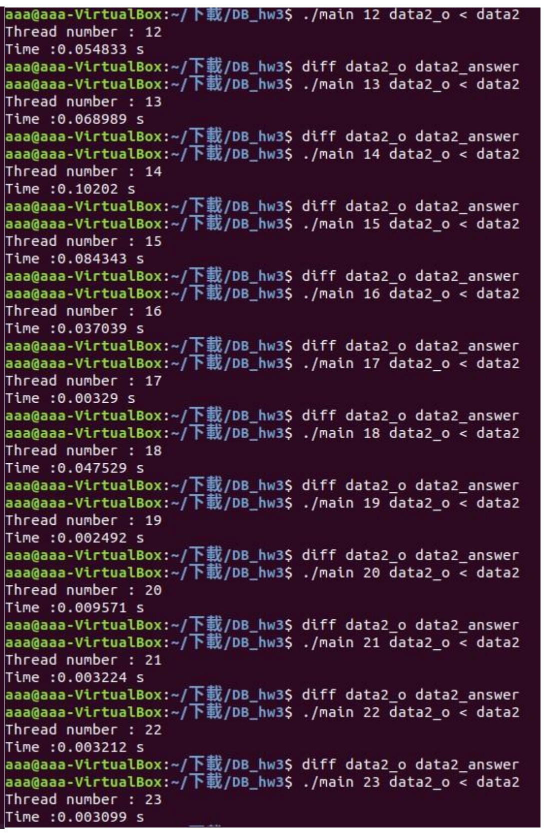
```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 10 data3_o <data3
Thread number : 10
Time :8.65401 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 11 data3_o <data3
Thread number : 11
Time :8.6243 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 11 data3_o <data3
Thread number : 11
Time :8.60154 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 30 data3_o <data3
Thread number : 30
Time :8.91227 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 35 data3_o <data3
Thread number : 35
Time :8.95963 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 50 data3_o <data3
Thread number : 50
Time :9.01913 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 71 data3_o <data3
Thread number : 71
Time :9.64423 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 80 data3_o <data3
Thread number : 80
Time :9.99642 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 71 data3_o <data3
Thread number : 71
Time :9.74736 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 80 data3_o <data3
Thread number : 80
Time :9.76983 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 90 data3_o <data3
Thread number : 90
Time :10.2134 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 100 data3_o <data3
Thread number : 100
Time :12.4948 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data3_o data3_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ █
```

2-2-3

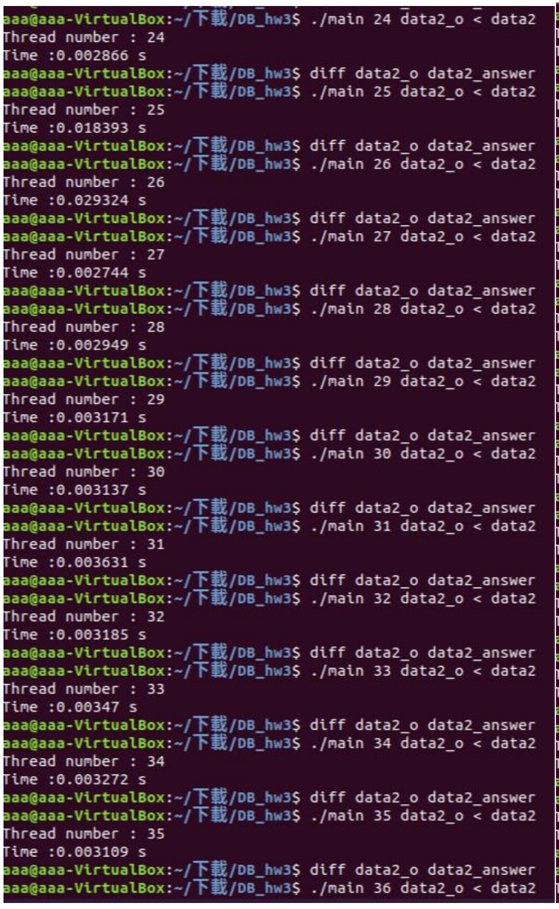
我測了很多組的資料都是可以的，所以應該是可以，以下為測試的截圖



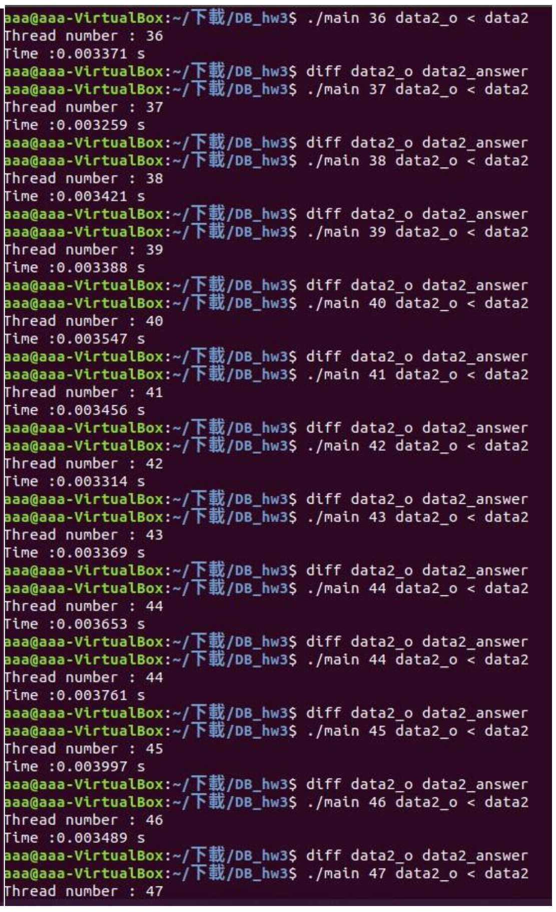
```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 1 data2_o < data2
Thread number : 1
Time :0.002019 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 2 data2_o < data2
Thread number : 2
Time :0.002231 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 3 data2_o < data2
Thread number : 3
Time :0.017454 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 4 data2_o < data2
Thread number : 4
Time :0.008216 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 5 data2_o < data2
Thread number : 5
Time :0.017195 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 6 data2_o < data2
Thread number : 6
Time :0.011502 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 7 data2_o < data2
Thread number : 7
Time :0.044812 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 8 data2_o < data2
Thread number : 8
Time :0.027608 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 9 data2_o < data2
Thread number : 9
Time :0.060725 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 10 data2_o < data2
Thread number : 10
Time :0.047429 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 11 data2_o < data2
Thread number : 11
Time :0.043384 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 12 data2_o < data2
Thread number : 12
```



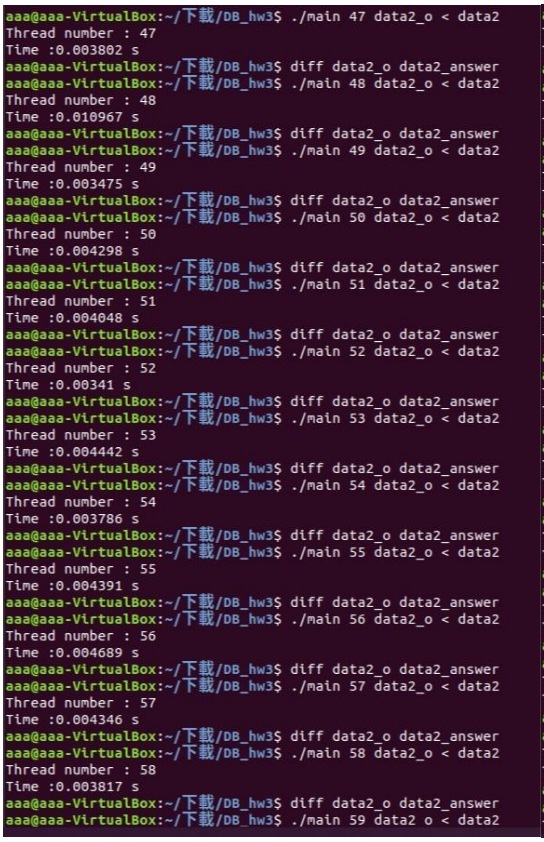
```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 12 data2_o < data2
Thread number : 12
Time :0.054833 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 13 data2_o < data2
Thread number : 13
Time :0.068989 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 14 data2_o < data2
Thread number : 14
Time :0.10202 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 15 data2_o < data2
Thread number : 15
Time :0.084343 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 16 data2_o < data2
Thread number : 16
Time :0.037039 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 17 data2_o < data2
Thread number : 17
Time :0.00329 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 18 data2_o < data2
Thread number : 18
Time :0.047529 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 19 data2_o < data2
Thread number : 19
Time :0.002492 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 20 data2_o < data2
Thread number : 20
Time :0.009571 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 21 data2_o < data2
Thread number : 21
Time :0.003224 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 22 data2_o < data2
Thread number : 22
Time :0.003212 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 23 data2_o < data2
Thread number : 23
Time :0.003099 s
```



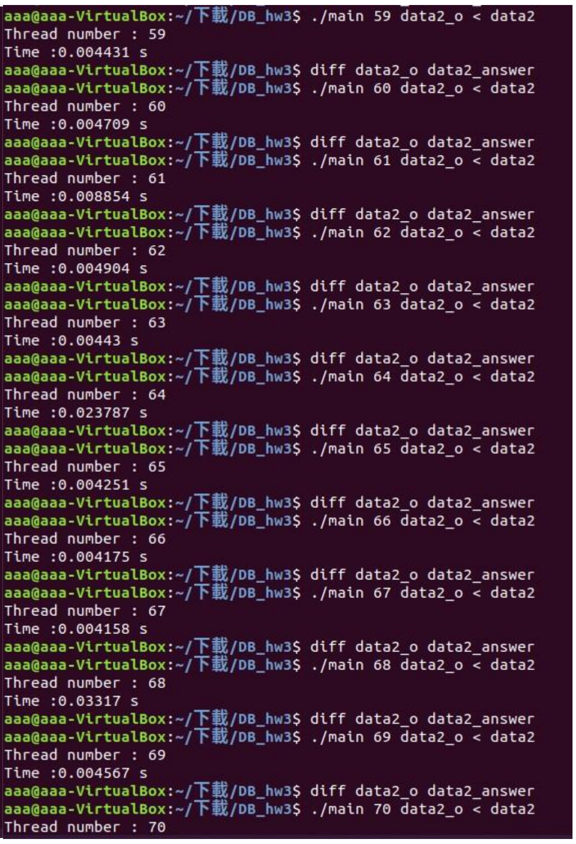
```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 24 data2_o < data2
Thread number : 24
Time :0.002866 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 25 data2_o < data2
Thread number : 25
Time :0.018393 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 26 data2_o < data2
Thread number : 26
Time :0.029324 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 27 data2_o < data2
Thread number : 27
Time :0.002744 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 28 data2_o < data2
Thread number : 28
Time :0.002949 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 29 data2_o < data2
Thread number : 29
Time :0.003171 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 30 data2_o < data2
Thread number : 30
Time :0.003137 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 31 data2_o < data2
Thread number : 31
Time :0.003631 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 32 data2_o < data2
Thread number : 32
Time :0.003185 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 33 data2_o < data2
Thread number : 33
Time :0.00347 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 34 data2_o < data2
Thread number : 34
Time :0.003272 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 35 data2_o < data2
Thread number : 35
Time :0.003109 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 36 data2_o < data2
```



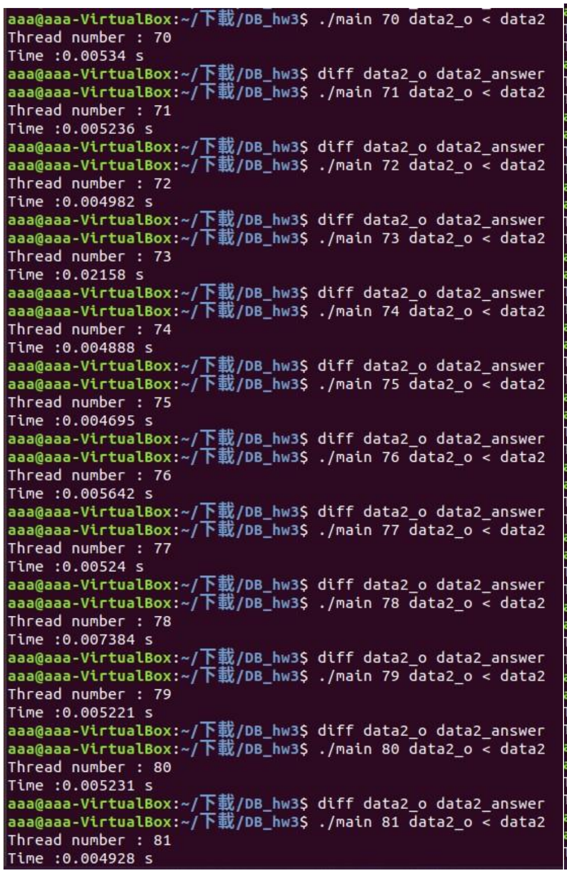
```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 36 data2_o < data2
Thread number : 36
Time :0.003371 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 37 data2_o < data2
Thread number : 37
Time :0.003259 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 38 data2_o < data2
Thread number : 38
Time :0.003421 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 39 data2_o < data2
Thread number : 39
Time :0.003388 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 40 data2_o < data2
Thread number : 40
Time :0.003547 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 41 data2_o < data2
Thread number : 41
Time :0.003456 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 42 data2_o < data2
Thread number : 42
Time :0.003314 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 43 data2_o < data2
Thread number : 43
Time :0.003369 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 44 data2_o < data2
Thread number : 44
Time :0.003653 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 44 data2_o < data2
Thread number : 44
Time :0.003761 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 45 data2_o < data2
Thread number : 45
Time :0.003997 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 46 data2_o < data2
Thread number : 46
Time :0.003489 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 47 data2_o < data2
Thread number : 47
```



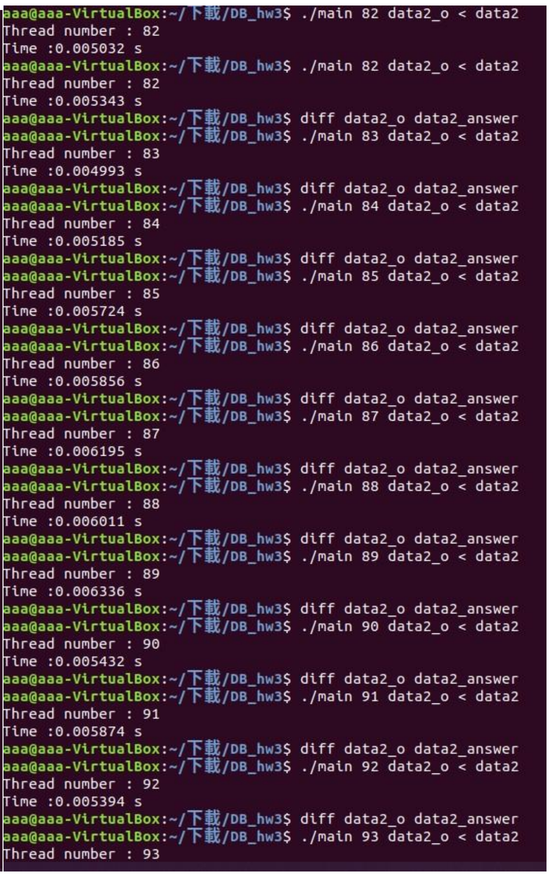
```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 47 data2_o < data2
Thread number : 47
Time :0.003802 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 48 data2_o < data2
Thread number : 48
Time :0.010967 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 49 data2_o < data2
Thread number : 49
Time :0.003475 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 50 data2_o < data2
Thread number : 50
Time :0.004298 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 51 data2_o < data2
Thread number : 51
Time :0.004048 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 52 data2_o < data2
Thread number : 52
Time :0.00341 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 53 data2_o < data2
Thread number : 53
Time :0.004442 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 54 data2_o < data2
Thread number : 54
Time :0.003786 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 55 data2_o < data2
Thread number : 55
Time :0.004391 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 56 data2_o < data2
Thread number : 56
Time :0.004689 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 57 data2_o < data2
Thread number : 57
Time :0.004346 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 58 data2_o < data2
Thread number : 58
Time :0.003817 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 59 data2 o < data2
```



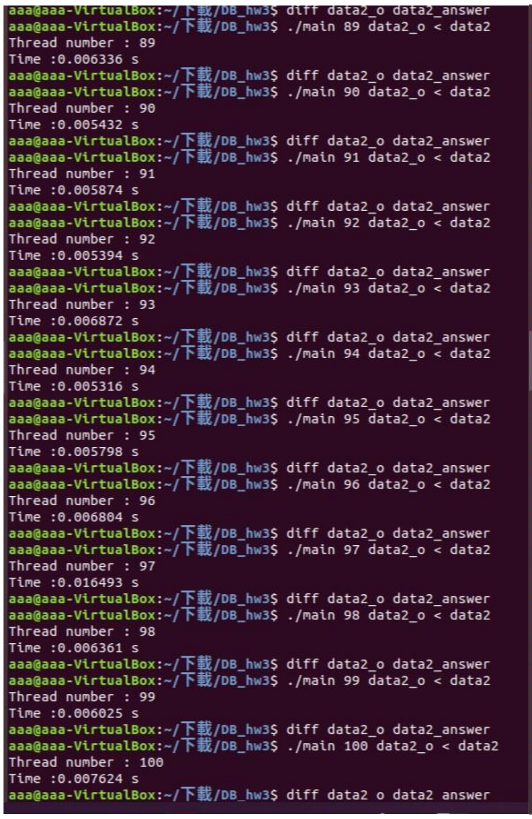
```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 59 data2_o < data2
Thread number : 59
Time :0.004431 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 60 data2_o < data2
Thread number : 60
Time :0.004709 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 61 data2_o < data2
Thread number : 61
Time :0.008854 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 62 data2_o < data2
Thread number : 62
Time :0.004904 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 63 data2_o < data2
Thread number : 63
Time :0.00443 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 64 data2_o < data2
Thread number : 64
Time :0.023787 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 65 data2_o < data2
Thread number : 65
Time :0.004251 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 66 data2_o < data2
Thread number : 66
Time :0.004175 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 67 data2_o < data2
Thread number : 67
Time :0.004158 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 68 data2_o < data2
Thread number : 68
Time :0.03317 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 69 data2_o < data2
Thread number : 69
Time :0.004567 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 70 data2_o < data2
Thread number : 70
```



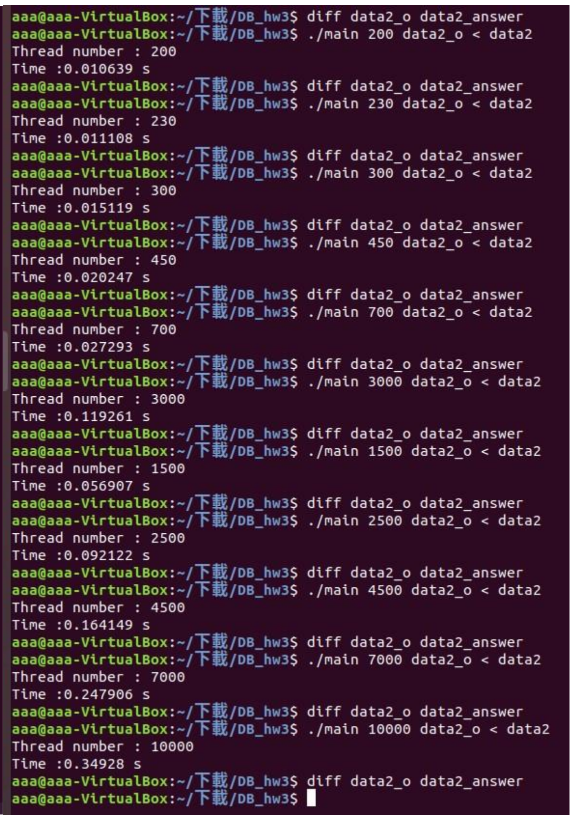
```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 70 data2_o < data2
Thread number : 70
Time :0.00534 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 71 data2_o < data2
Thread number : 71
Time :0.005236 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 72 data2_o < data2
Thread number : 72
Time :0.004982 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 73 data2_o < data2
Thread number : 73
Time :0.02158 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 74 data2_o < data2
Thread number : 74
Time :0.004888 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 75 data2_o < data2
Thread number : 75
Time :0.004695 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 76 data2_o < data2
Thread number : 76
Time :0.005642 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 77 data2_o < data2
Thread number : 77
Time :0.00524 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 78 data2_o < data2
Thread number : 78
Time :0.007384 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 79 data2_o < data2
Thread number : 79
Time :0.005221 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 80 data2_o < data2
Thread number : 80
Time :0.005231 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 81 data2_o < data2
Thread number : 81
Time :0.004928 s
```



```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 82 data2_o < data2
Thread number : 82
Time :0.005032 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 82 data2_o < data2
Thread number : 82
Time :0.005343 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 83 data2_o < data2
Thread number : 83
Time :0.004993 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 84 data2_o < data2
Thread number : 84
Time :0.005185 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 85 data2_o < data2
Thread number : 85
Time :0.005724 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 86 data2_o < data2
Thread number : 86
Time :0.005856 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 87 data2_o < data2
Thread number : 87
Time :0.006195 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 88 data2_o < data2
Thread number : 88
Time :0.006011 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 89 data2_o < data2
Thread number : 89
Time :0.006336 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 90 data2_o < data2
Thread number : 90
Time :0.005432 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 91 data2_o < data2
Thread number : 91
Time :0.005874 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 92 data2_o < data2
Thread number : 92
Time :0.005394 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 93 data2_o < data2
Thread number : 93
```



```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 89 data2_o < data2
Thread number : 89
Time :0.006336 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 90 data2_o < data2
Thread number : 90
Time :0.005432 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 91 data2_o < data2
Thread number : 91
Time :0.005874 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 92 data2_o < data2
Thread number : 92
Time :0.005394 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 93 data2_o < data2
Thread number : 93
Time :0.006872 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 94 data2_o < data2
Thread number : 94
Time :0.005316 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 95 data2_o < data2
Thread number : 95
Time :0.005798 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 96 data2_o < data2
Thread number : 96
Time :0.006804 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 97 data2_o < data2
Thread number : 97
Time :0.016493 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 98 data2_o < data2
Thread number : 98
Time :0.006361 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 99 data2_o < data2
Thread number : 99
Time :0.006025 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 100 data2_o < data2
Thread number : 100
Time :0.007624 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
```



```
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 200 data2_o < data2
Thread number : 200
Time :0.010639 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 230 data2_o < data2
Thread number : 230
Time :0.011108 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 300 data2_o < data2
Thread number : 300
Time :0.015119 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 450 data2_o < data2
Thread number : 450
Time :0.020247 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 700 data2_o < data2
Thread number : 700
Time :0.027293 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 3000 data2_o < data2
Thread number : 3000
Time :0.119261 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 1500 data2_o < data2
Thread number : 1500
Time :0.056907 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 2500 data2_o < data2
Thread number : 2500
Time :0.092122 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 4500 data2_o < data2
Thread number : 4500
Time :0.164149 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 7000 data2_o < data2
Thread number : 7000
Time :0.247906 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ ./main 10000 data2_o < data2
Thread number : 10000
Time :0.34928 s
aaa@aaa-VirtualBox:~/下載/DB_hw3$ diff data2_o data2_answer
aaa@aaa-VirtualBox:~/下載/DB_hw3$ 
```