Parallel and Distributed Computing

Project Report

Sorting Tabular Rows Exhibiting

OpenMP VS Sequential

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Introduction:

The OpenMP API supports multi-platform shared-memory parallel programming in C/C++ and Fortran. The OpenMP API defines a portable, scalable model with a simple and flexible interface for developing parallel applications on platforms from the desktop to the supercomputer.
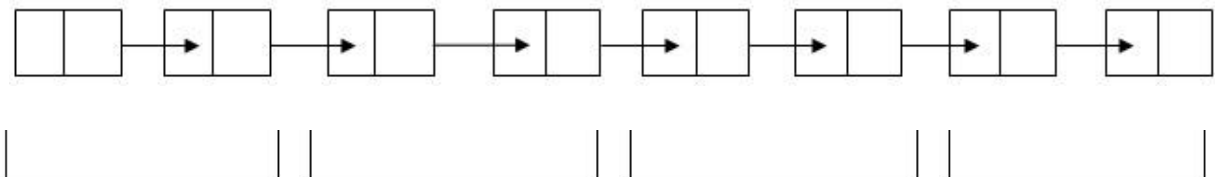
Contrary to that sequential programming runs your code line by line, in a default control structure. This approach might take more time then parallel programming as the resources are not shared in sequential programming.

In this project we will be sorting tabular data parallel through OpenMP and sequentially. Then the difference would be presented through graphical analysis on the basis of time consumption by both the methods.

The data structure used for this project is Linked List, and the sorting we used is Merge Sort. Merge Sort is well known algorithm which is based on divide and conquer approach, and so we have used Linked List as it is easy to divide data in it comparatively to other data structures and this will be helpful for input-intermediate-output data decomposition.
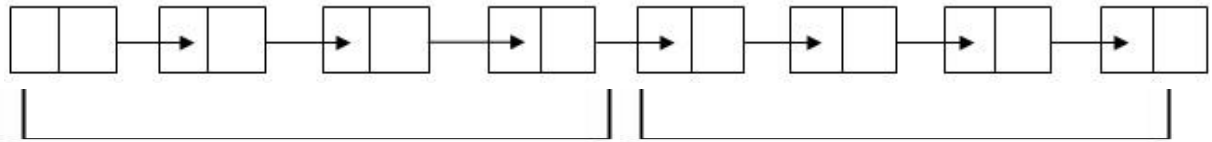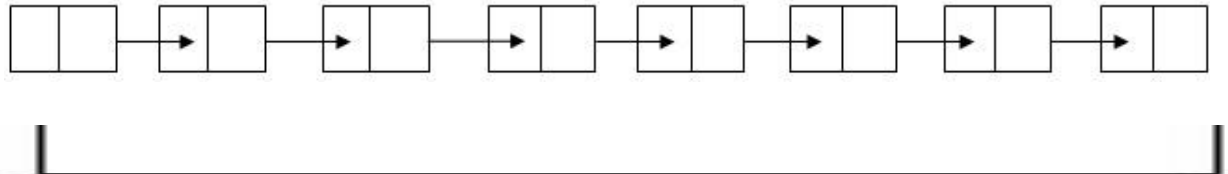
System Diagram

No. of threads = 4

Each thread will break Linked List into equal chuck sizes, and will apply Merge Sort on its own input data. After applying the Merge Sort, Number of threads will decrease and chunk sizes will increase.

No. of threads = 2

No. of threads = 1

Source Data Description

```
employee.txt - Notepad
File   Edit   Format   View   Help
0  snkex  18182  d
1  raxoh  6043   c
2  ftixz  16081  c
3  cxfbe  1639   b
4  xaqau  18739  b
5  ngaou  2684   c
6  csgna  694    b
7  oqgaa  3951   c
8  mxwhg  361    b
9  ykrqy  7186   b
10 xmdee  18890  c
11 pxuph  6259   b
12 pmacm  9456   b
13 lrxze  16445  d
14 nabfo  366    c
15 rxqdz  18548  b
16 uromj  4748   b
17 urnyj  10694  d
18 kaswj  18590  d
19 gjugk  8304   a
20 oecao  2058   d
21 qmoxn  10652  b
22 uffni  8314   c
23 rrasd  10918  c
24 mqnox  16106  b
25 fpsll  6447   a
26 sfgza  17879  a
27 ssxnu  4007   b
28 qutyt  8687   c
29 yekns  19276  a
30 jcubf  2309   b
31 qaylj  17434  d
32 grmve  18309  c
33 bpevr  2169   b
34 txkkm  16673  c
35 qrmxu  8819   a
```

This text file is our source data, it is a record of 500 employees. It consists of a person's id, name, salary and department.

```
{
    #pragma omp for schedule(dynamic)
    for (int i = 0; i < ListSize; i++)
        insert(&head, emp[i]);
}
```

In this parallel region, we are placing our input file data into Linked List parallel using "#pragma omp for", and we are using dynamic scheduling in it.

```
#pragma omp parallel num_threads(threadsize) shared(head,choice) private(temp1,threadnum,str)
{

    Node* temp1 = NULL;
    #pragma omp for schedule(static)
    for (int i = 0; i < ListSize; i++)
    {
        #pragma omp critical
        {
            /*int threadnum = omp_get_thread_num();*/
            insert(&temp1, head->data);

            //cout << "thread id: " << threadnum << " inserted record with id: " << head->data.id << endl;
            deleteNode(&head, head);
        }
    }
}
```

In this parallel region, multiple threads are being created, the number of threads is stored in threadsize variable. There are two parameters that are shared, one is the head which is the head node of our linked list. And the second one is the choice, in which the user is selecting the option according to which input category, the data should be sorted. Lastly temp1 is a private parameter which is used for input data decomposition, as each thread will make its own Linked List.

The next block is of Input data decomposition, in this we are using "omp for" directives and in that for directive we are using "omp critical" directive as Linked Lists are dependent data structure because every next node is dependent over

the previous node's pointer, critical region stops the thread from interfering in between loop iterations and mixing up the pointers and nodes.

Lastly each thread is inserting a node into its private Linked List and deleting the node from primary Linked List.

```cpp
if (divider == 2)
{

    #pragma omp critical
    {
        str = " and I have data : ";
        print(temp1,omp_get_thread_num(),str);
    }
}

temp1 = mergeSort(temp1, choice);

if (divider == 2)
{

    #pragma omp critical
    {
        str = " and I sorted data : ";
        print(temp1, omp_get_thread_num(), str);
    }
}
```

This block is used for printing intermediate results into local results file.

```cpp
#pragma omp for schedule(static)
for (int i = 0; i < ListSize; i++)
{
    #pragma omp critical
    {
        append(&head, temp1->data);
        deleteNode(&temp1, temp1);
        //cout << endl; print(head); cout << endl;   //Remove Bar to observe cycles :)
    }
}
```

In this block, Output data decomposition is taking place. Each thread is adding its sorted nodes into the primary Linked List and deleting it from the private temp1 Linked List.

Snapshots of Input Data (On Each Thread)

Local Input Data of Each Thread at 4 threads

```
Hi this is thread : 1  and I have data : 27    ssxnu   4007    b        Hi this is thread : 3  and I have data : 34    txkkm   16673   c
Hi this is thread : 1  and I have data : 30    jcubf   2309    b        Hi this is thread : 3  and I have data : 36    ynjfy   2354    c
Hi this is thread : 1  and I have data : 35    qrmxu   8819    a        Hi this is thread : 3  and I have data : 40    qkyjx   19617   d
Hi this is thread : 1  and I have data : 39    aiqax   1845    b        Hi this is thread : 3  and I have data : 41    svhhd   15653   a
Hi this is thread : 1  and I have data : 42    vetzu   6351    b        Hi this is thread : 3  and I have data : 43    xvpnx   6087    b
Hi this is thread : 1  and I have data : 44    ldstg   11498   b        Hi this is thread : 3  and I have data : 22    uffni   8314    c
Hi this is thread : 1  and I have data : 45    xtzco   5865    d        Hi this is thread : 3  and I have data : 54    aegyi   9611    c
Hi this is thread : 1  and I have data : 47    derbb   12276   d        Hi this is thread : 3  and I have data : 55    qkehs   9764    c
Hi this is thread : 1  and I have data : 49    toyhk   3621    b        Hi this is thread : 3  and I have data : 61    yguip   3732    b
Hi this is thread : 1  and I have data : 48    fijvk   11429   d        Hi this is thread : 3  and I have data : 89    zlkuc   18828   d
Hi this is thread : 1  and I have data : 50    qthkn   853     c        Hi this is thread : 3  and I have data : 99    bolmk   9574    a
Hi this is thread : 1  and I have data : 51    pgzqb   17895   a        Hi this is thread : 3  and I have data : 100   kxzwk   3143    b
Hi this is thread : 1  and I have data : 52    zebix   11856   b        Hi this is thread : 3  and I have data : 104   scnrn   13638   b
Hi this is thread : 1  and I have data : 62    utfri   4850    b        Hi this is thread : 3  and I have data : 124   lfxzs   11224   b
Hi this is thread : 1  and I have data : 60    wsobc   14756   c        Hi this is thread : 3  and I have data : 126   xcvad   15971   a
Hi this is thread : 1  and I have data : 64    hoxwo   1374    c        Hi this is thread : 3  and I have data : 125   mndty   12523   c
Hi this is thread : 1  and I have data : 67    uddrv   10177   d        Hi this is thread : 3  and I have data : 123   mslwo   11049   c
Hi this is thread : 1  and I have data : 70    vottr   7405    d        Hi this is thread : 3  and I have data : 130   hrfbw   11662   b
Hi this is thread : 1  and I have data : 68    qgupx   3334    c        Hi this is thread : 3  and I have data : 127   hzcff   17278   c
Hi this is thread : 1  and I have data : 72    prmru   7064    d        Hi this is thread : 3  and I have data : 131   ppihs   13340   b
Hi this is thread : 1  and I have data : 73    agemc   14100   b        Hi this is thread : 3  and I have data : 133   pzfhz   3865    d
Hi this is thread : 1  and I have data : 75    hrecs   7433    a        Hi this is thread : 3  and I have data : 136   jzunu   452     c
Hi this is thread : 1  and I have data : 77    snepg   8234    c        Hi this is thread : 3  and I have data : 137   mrlgk   12138   c
Hi this is thread : 1  and I have data : 87    mvtrd   2270    c        Hi this is thread : 3  and I have data : 139   aymlk   2520    b
Hi this is thread : 1  and I have data : 90    yskui   11148   a        Hi this is thread : 3  and I have data : 138   wrhcy   12127   c
Hi this is thread : 1  and I have data : 88    baaxp   14399   a        Hi this is thread : 3  and I have data : 141   vyman   8711    c
Hi this is thread : 1  and I have data : 93    txhej   16331   b        Hi this is thread : 3  and I have data : 143   ncntk   8389    a
Hi this is thread : 1  and I have data : 92    onaft   8350    d        Hi this is thread : 3  and I have data : 144   xrnam   3250    c
Hi this is thread : 1  and I have data : 95    cvmxv   10435   a        Hi this is thread : 3  and I have data : 146   krfzh   16001   c
Hi this is thread : 1  and I have data : 98    nxuvu   1415    c        Hi this is thread : 3  and I have data : 147   junsx   13042   b
Hi this is thread : 1  and I have data : 101   kdlvv   1593    b        Hi this is thread : 3  and I have data : 149   hlslu   14577   d
Hi this is thread : 1  and I have data : 103   tqtdu   19735   d        Hi this is thread : 3  and I have data : 148   tvcty   15847   a
Hi this is thread : 1  and I have data : 105   cwxmw   9049    d        Hi this is thread : 3  and I have data : 152   rjilb   3745    c
Hi this is thread : 1  and I have data : 107   dupdg   6641    b        Hi this is thread : 3  and I have data : 158   fcksq   12918   c
Hi this is thread : 1  and I have data : 111   gyvat   7413    a        Hi this is thread : 3  and I have data : 164   nzoyk   4237    b
Hi this is thread : 1  and I have data : 110   vpmns   11388   d        Hi this is thread : 3  and I have data : 178   twnpg   7692    d
Hi this is thread : 1  and I have data : 122   uoagt   7145    a        Hi this is thread : 3  and I have data : 182   dnorc   12133   a
Hi this is thread : 1  and I have data : 155   yfpvb   10036   c        Hi this is thread : 3  and I have data : 181   lphwz   3307    d
Hi this is thread : 1  and I have data : 156   flaqk   7848    a        Hi this is thread : 3  and I have data : 183   etxhm   4448    b
Hi this is thread : 1  and I have data : 157   haiel   2026    a        Hi this is thread : 3  and I have data : 185   ptpnk   722     b
Hi this is thread : 1  and I have data : 159   jqrff   13682   b        Hi this is thread : 3  and I have data : 187   stngd   5265    b
Hi this is thread : 1  and I have data : 161   evmtn   7255    b        Hi this is thread : 3  and I have data : 194   yufif   18651   c
Hi this is thread : 1  and I have data : 162   opqgk   1762    a        Hi this is thread : 3  and I have data : 208   nfayy   3574    d
Hi this is thread : 1  and I have data : 163   gmhcr   17498   d        Hi this is thread : 3  and I have data : 222   ygndr   5899    a
Hi this is thread : 1  and I have data : 160   raugs   5874    a        Hi this is thread : 3  and I have data : 225   glufe   18270   a
Hi this is thread : 1  and I have data : 165   lqmsy   3255    b        Hi this is thread : 3  and I have data : 239   sjyoy   15926   b
Hi this is thread : 1  and I have data : 166   hsvrp   6396    b        Hi this is thread : 3  and I have data : 242   ofeim   12238   b
                                                                        Hi this is thread : 3  and I have data : 246   adabd   8891    a
                                                                        Hi this is thread : 3  and I have data : 251   vdget   2050    b
                                                                        Hi this is thread : 3  and I have data : 253   ggcje   2486    c
```

```
Hi this is thread : 2  and I have data : 19    gjugk   8304    a     Hi this is thread : 0  and I have data : 174   bgneo   17977   b
Hi this is thread : 2  and I have data : 21    qmoxn   10652   b     Hi this is thread : 0  and I have data : 177   bakzx   9020    d
Hi this is thread : 2  and I have data : 23    rrasd   10918   c     Hi this is thread : 0  and I have data : 176   xsqbw   13041   b
Hi this is thread : 2  and I have data : 26    sfgza   17879   c     Hi this is thread : 0  and I have data : 179   vsehk   14346   b
Hi this is thread : 2  and I have data : 29    yekns   19276   a     Hi this is thread : 0  and I have data : 180   vjwfm   256     b
Hi this is thread : 2  and I have data : 33    bpevr   2169    b     Hi this is thread : 0  and I have data : 184   zzgzm   15795   c
Hi this is thread : 2  and I have data : 37    nesoc   2515    c     Hi this is thread : 0  and I have data : 186   aoldt   16609   b
Hi this is thread : 2  and I have data : 38    cknrg   445     a     Hi this is thread : 0  and I have data : 190   ugrrq   6267    b
Hi this is thread : 2  and I have data : 46    jcjoc   9976    d     Hi this is thread : 0  and I have data : 193   vlcuw   447     b
Hi this is thread : 2  and I have data : 56    csaqt   18367   b     Hi this is thread : 0  and I have data : 197   gjfal   5035    a
Hi this is thread : 2  and I have data : 78    ysrdf   15327   a     Hi this is thread : 0  and I have data : 205   ulnwl   2867    d
Hi this is thread : 2  and I have data : 79    lvpub   3266    d     Hi this is thread : 0  and I have data : 207   lzwxr   2078    a
Hi this is thread : 2  and I have data : 82    uipye   3069    b     Hi this is thread : 0  and I have data : 211   sjbyy   2877    b
Hi this is thread : 2  and I have data : 85    bsqlz   14387   a     Hi this is thread : 0  and I have data : 214   riqcy   11082   b
Hi this is thread : 2  and I have data : 86    eefzj   16783   b     Hi this is thread : 0  and I have data : 215   rrgvn   8087    a
Hi this is thread : 2  and I have data : 91    ajjql   3257    a     Hi this is thread : 0  and I have data : 218   logth   5899    b
Hi this is thread : 2  and I have data : 94    ycvyo   5609    c     Hi this is thread : 0  and I have data : 221   edegv   9064    d
Hi this is thread : 2  and I have data : 102   eqzve   11580   a     Hi this is thread : 0  and I have data : 224   qffay   9378    d
Hi this is thread : 2  and I have data : 109   avokj   17398   c     Hi this is thread : 0  and I have data : 228   lxjsj   19077   a
Hi this is thread : 2  and I have data : 114   fqplt   18287   a     Hi this is thread : 0  and I have data : 229   mgcwp   17676   c
Hi this is thread : 2  and I have data : 115   kichl   319     d     Hi this is thread : 0  and I have data : 234   ymhmc   7371    b
Hi this is thread : 2  and I have data : 117   vhucm   9777    c     Hi this is thread : 0  and I have data : 236   bhelt   188     c
Hi this is thread : 2  and I have data : 119   aiaxr   18987   c     Hi this is thread : 0  and I have data : 237   gcypb   12862   a
Hi this is thread : 2  and I have data : 120   ywqrn   3842    a     Hi this is thread : 0  and I have data : 240   bqhjs   9176    c
Hi this is thread : 2  and I have data : 121   mzyor   19144   d     Hi this is thread : 0  and I have data : 244   wzucn   12843   c
Hi this is thread : 2  and I have data : 128   mhcsd   7517    b     Hi this is thread : 0  and I have data : 245   lrctg   12172   a
Hi this is thread : 2  and I have data : 129   uvtmf   14413   a     Hi this is thread : 0  and I have data : 248   qocme   6291    b
Hi this is thread : 2  and I have data : 132   hzyxp   13195   d     Hi this is thread : 0  and I have data : 257   fifan   2892    d
Hi this is thread : 2  and I have data : 134   gzpkw   10276   d     Hi this is thread : 0  and I have data : 259   uzuqn   7734    c
Hi this is thread : 2  and I have data : 135   aaolw   835     c     Hi this is thread : 0  and I have data : 261   lbmde   18388   b
Hi this is thread : 2  and I have data : 140   gaiyi   6776    b     Hi this is thread : 0  and I have data : 269   mugax   6542    c
Hi this is thread : 2  and I have data : 142   ubuzo   18728   b     Hi this is thread : 0  and I have data : 309   kfuky   10644   d
Hi this is thread : 2  and I have data : 145   iiuyf   7906    d     Hi this is thread : 0  and I have data : 311   ywvzx   12368   b
Hi this is thread : 2  and I have data : 150   hxbkt   5140    c     Hi this is thread : 0  and I have data : 421   qsqnp   6263    b
Hi this is thread : 2  and I have data : 189   yqmly   16065   b     Hi this is thread : 0  and I have data : 422   grqxb   8347    b
Hi this is thread : 2  and I have data : 198   trwhq   8443    b     Hi this is thread : 0  and I have data : 423   abfqm   17398   d
Hi this is thread : 2  and I have data : 199   coupd   12488   d     Hi this is thread : 0  and I have data : 424   hnzif   9000    a
Hi this is thread : 2  and I have data : 201   dqalw   16595   a     Hi this is thread : 0  and I have data : 426   igaqb   9717    c
Hi this is thread : 2  and I have data : 202   ahaie   17436   b     Hi this is thread : 0  and I have data : 428   orxux   5451    c
Hi this is thread : 2  and I have data : 203   xkqeb   3712    c     Hi this is thread : 0  and I have data : 430   ddqrc   11871   d
Hi this is thread : 2  and I have data : 206   digts   15368   b     Hi this is thread : 0  and I have data : 432   mfwll   18068   d
Hi this is thread : 2  and I have data : 209   idzrh   19216   b     Hi this is thread : 0  and I have data : 445   pxwov   5618    c
Hi this is thread : 2  and I have data : 210   dpzct   14057   a     Hi this is thread : 0  and I have data : 446   vkbod   7537    c
Hi this is thread : 2  and I have data : 213   hdcvy   918     a     Hi this is thread : 0  and I have data : 447   yqpym   15921   b
Hi this is thread : 2  and I have data : 212   enzvb   4537    c     Hi this is thread : 0  and I have data : 448   nogaq   15603   b
Hi this is thread : 2  and I have data : 216   anfsq   6321    b     Hi this is thread : 0  and I have data : 449   sckuy   6711    b
Hi this is thread : 2  and I have data : 220   yfzgr   268     c     Hi this is thread : 0  and I have data : 450   zozga   792     c
Hi this is thread : 2  and I have data : 223   vnvnk   3046    b     Hi this is thread : 0  and I have data : 451   clvvu   1943    b
Hi this is thread : 2  and I have data : 226   cwbqx   11249   a     Hi this is thread : 0  and I have data : 452   tjxnf   9943    b
Hi this is thread : 2  and I have data : 235   eyctp   12978   c     Hi this is thread : 0  and I have data : 453   hzuik   5625    d
Hi this is thread : 2  and I have data : 243   wltcl   1445    c
```

Snapshots of Output Data (On Each Thread)

Local Output Data of Each Thread at 4 threads

```
Hi this is thread : 1  and I sorted data : 204   abqom   7419    a     Hi this is thread : 2  and I sorted data : 33    bpevr   2169    b
Hi this is thread : 1  and I sorted data : 73    agemc   14100   b     Hi this is thread : 2  and I sorted data : 85    bsqlz   14387   a
Hi this is thread : 1  and I sorted data : 39    aiqax   1845    b     Hi this is thread : 2  and I sorted data : 406   cixid   17580   d
Hi this is thread : 1  and I sorted data : 348   apdsh   14754   c     Hi this is thread : 2  and I sorted data : 301   ckmur   8473    a
Hi this is thread : 1  and I sorted data : 262   atlth   11891   c     Hi this is thread : 2  and I sorted data : 38    cknrg   445     a
Hi this is thread : 1  and I sorted data : 233   awqmo   1306    d     Hi this is thread : 2  and I sorted data : 199   coupd   12488   d
Hi this is thread : 1  and I sorted data : 88    baaxp   14399   a     Hi this is thread : 2  and I sorted data : 56    csaqt   18367   b
Hi this is thread : 1  and I sorted data : 191   bbcbl   3287    c     Hi this is thread : 2  and I sorted data : 335   cvitv   9711    c
Hi this is thread : 1  and I sorted data : 195   bgerm   9464    c     Hi this is thread : 2  and I sorted data : 226   cwbqx   11249   a
Hi this is thread : 1  and I sorted data : 288   bofdp   9176    d     Hi this is thread : 2  and I sorted data : 275   cyhgu   8089    a
Hi this is thread : 1  and I sorted data : 346   bpjeq   16060   a     Hi this is thread : 2  and I sorted data : 268   ddjvm   5704    c
Hi this is thread : 1  and I sorted data : 232   bqjhr   15372   d     Hi this is thread : 2  and I sorted data : 206   digts   15368   b
Hi this is thread : 1  and I sorted data : 398   byvxa   9117    a     Hi this is thread : 2  and I sorted data : 393   djaty   8449    b
Hi this is thread : 1  and I sorted data : 188   cqtcl   9255    b     Hi this is thread : 2  and I sorted data : 391   dkqpk   8328    b
Hi this is thread : 1  and I sorted data : 167   csorq   5014    a     Hi this is thread : 2  and I sorted data : 210   dpzct   14057   a
Hi this is thread : 1  and I sorted data : 329   cumpx   4030    a     Hi this is thread : 2  and I sorted data : 201   dqalw   16595   a
Hi this is thread : 1  and I sorted data : 95    cvmxv   10435   a     Hi this is thread : 2  and I sorted data : 86    eefzj   16783   b
Hi this is thread : 1  and I sorted data : 105   cwxmw   9049    d     Hi this is thread : 2  and I sorted data : 212   enzvb   4537    c
Hi this is thread : 1  and I sorted data : 400   ddxzl   2472    a     Hi this is thread : 2  and I sorted data : 380   eqdyu   10032   a
Hi this is thread : 1  and I sorted data : 47    derbb   12276   d     Hi this is thread : 2  and I sorted data : 102   eqzve   11580   a
Hi this is thread : 1  and I sorted data : 315   dmyty   7581    d     Hi this is thread : 2  and I sorted data : 357   esopr   10812   a
Hi this is thread : 1  and I sorted data : 296   dptef   941     c     Hi this is thread : 2  and I sorted data : 235   eyctp   12978   c
Hi this is thread : 1  and I sorted data : 107   dupdg   6641    b     Hi this is thread : 2  and I sorted data : 289   fmiwl   14369   b
Hi this is thread : 1  and I sorted data : 247   ecynh   1889    d     Hi this is thread : 2  and I sorted data : 114   fqplt   18287   a
Hi this is thread : 1  and I sorted data : 267   eqtxv   14050   c     Hi this is thread : 2  and I sorted data : 385   frdtk   11928   d
Hi this is thread : 1  and I sorted data : 161   evmtn   7255    b     Hi this is thread : 2  and I sorted data : 436   fsibs   8378    b
Hi this is thread : 1  and I sorted data : 333   ffqbh   11960   c     Hi this is thread : 2  and I sorted data : 356   fuhty   19693   a
Hi this is thread : 1  and I sorted data : 48    fijvk   11429   d     Hi this is thread : 2  and I sorted data : 140   gaiyi   6776    b
Hi this is thread : 1  and I sorted data : 156   flaqk   7848    a     Hi this is thread : 2  and I sorted data : 19    gjugk   8304    a
Hi this is thread : 1  and I sorted data : 219   frtzq   11481   a     Hi this is thread : 2  and I sorted data : 408   gvwsi   10680   c
Hi this is thread : 1  and I sorted data : 173   ftuab   6259    d     Hi this is thread : 2  and I sorted data : 134   gzpkw   10276   d
Hi this is thread : 1  and I sorted data : 401   fviuu   8032    a     Hi this is thread : 2  and I sorted data : 316   hcikg   6419    a
Hi this is thread : 1  and I sorted data : 163   gmhcr   17498   d     Hi this is thread : 2  and I sorted data : 213   hdcvy   918     a
Hi this is thread : 1  and I sorted data : 336   gsjli   14017   c     Hi this is thread : 2  and I sorted data : 359   hdepr   4834    a
Hi this is thread : 1  and I sorted data : 293   gwydx   5881    a     Hi this is thread : 2  and I sorted data : 440   hjdeh   8647    d
Hi this is thread : 1  and I sorted data : 350   gynik   17006   c     Hi this is thread : 2  and I sorted data : 379   hrphq   2720    b
Hi this is thread : 1  and I sorted data : 111   gyvat   7413    a     Hi this is thread : 2  and I sorted data : 150   hxbkt   5140    c
Hi this is thread : 1  and I sorted data : 157   haiel   2026    a     Hi this is thread : 2  and I sorted data : 132   hzyxp   13195   d
Hi this is thread : 1  and I sorted data : 331   hgkge   5724    b     Hi this is thread : 2  and I sorted data : 209   idzrh   19216   b
Hi this is thread : 1  and I sorted data : 64    hoxwo   1374    c     Hi this is thread : 2  and I sorted data : 145   iiuyf   7906    d
Hi this is thread : 1  and I sorted data : 75    hrecs   7433    a     Hi this is thread : 2  and I sorted data : 318   ijtnl   5286    b
Hi this is thread : 1  and I sorted data : 290   hrscs   12564   d     Hi this is thread : 2  and I sorted data : 46    jcjoc   9976    d
Hi this is thread : 1  and I sorted data : 166   hsvrp   6396    b     Hi this is thread : 2  and I sorted data : 340   jpjkj   932     a
Hi this is thread : 1  and I sorted data : 227   ietwn   19119   b     Hi this is thread : 2  and I sorted data : 266   jsevq   17189   a
Hi this is thread : 1  and I sorted data : 307   ifkbj   12242   c     Hi this is thread : 2  and I sorted data : 18    kaswj   18590   d
Hi this is thread : 1  and I sorted data : 230   iievm   12219   a     Hi this is thread : 2  and I sorted data : 115   kichl   319     d
Hi this is thread : 1  and I sorted data : 192   inaod   1569    a     Hi this is thread : 2  and I sorted data : 354   kohqa   13707   a
Hi this is thread : 1  and I sorted data : 231   iwklz   12946   b     Hi this is thread : 2  and I sorted data : 435   kwptm   17823   b
Hi this is thread : 1  and I sorted data : 196   iwkvm   8035    b     Hi this is thread : 2  and I sorted data : 345   lnwup   2177    d
Hi this is thread : 1  and I sorted data : 30    jcubf   2309    b     Hi this is thread : 2  and I sorted data : 297   lphbd   10760   b
Hi this is thread : 1  and I sorted data : 254   iczes   7293    d     Hi this is thread : 2  and I sorted data : 13    lrxze   16445   d
```

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Hi this is thread : 3  and I sorted data : 425  cqvex  11613  a       Hi this is thread : 0  and I sorted data : 430  ddqrc  11871  d
Hi this is thread : 3  and I sorted data : 6    csgna  694    b       Hi this is thread : 0  and I sorted data : 59   deloq  11307  b
Hi this is thread : 3  and I sorted data : 429  cuxom  11997  c       Hi this is thread : 0  and I sorted data : 80   dpqzo  15172  b
Hi this is thread : 3  and I sorted data : 3    cxfbe  1639   b       Hi this is thread : 0  and I sorted data : 475  dqdcc  3015   c
Hi this is thread : 3  and I sorted data : 182  dnorc  12133  a       Hi this is thread : 0  and I sorted data : 490  ebndz  3921   c
Hi this is thread : 3  and I sorted data : 363  dwzdk  15703  b       Hi this is thread : 0  and I sorted data : 221  edegv  9064   d
Hi this is thread : 3  and I sorted data : 404  ejsxe  18173  d       Hi this is thread : 0  and I sorted data : 481  eovvv  9261   d
Hi this is thread : 3  and I sorted data : 314  enluw  11109  b       Hi this is thread : 0  and I sorted data : 488  expvy  9347   a
Hi this is thread : 3  and I sorted data : 365  eslxr  13507  a       Hi this is thread : 0  and I sorted data : 491  fasnv  10209  a
Hi this is thread : 3  and I sorted data : 183  etxhm  4448   b       Hi this is thread : 0  and I sorted data : 257  fifan  2892   d
Hi this is thread : 3  and I sorted data : 412  ewoch  4917   a       Hi this is thread : 0  and I sorted data : 484  fjqle  6526   b
Hi this is thread : 3  and I sorted data : 366  fcczp  18497  a       Hi this is thread : 0  and I sorted data : 53   fvvbj  927    d
Hi this is thread : 3  and I sorted data : 158  fcksq  12918  c       Hi this is thread : 0  and I sorted data : 454  fvwgu  10587  c
Hi this is thread : 3  and I sorted data : 25   fpsll  6447   a       Hi this is thread : 0  and I sorted data : 237  gcypb  12862  a
Hi this is thread : 3  and I sorted data : 284  frpyo  618    a       Hi this is thread : 0  and I sorted data : 74   gipgb  13870  c
Hi this is thread : 3  and I sorted data : 2    ftixz  16081  c       Hi this is thread : 0  and I sorted data : 197  gjfal  5035   a
Hi this is thread : 3  and I sorted data : 384  fvfln  661    c       Hi this is thread : 0  and I sorted data : 460  gpswr  4238   a
Hi this is thread : 3  and I sorted data : 332  fwijd  3392   b       Hi this is thread : 0  and I sorted data : 478  gqsub  4561   b
Hi this is thread : 3  and I sorted data : 386  gbzjh  15227  d       Hi this is thread : 0  and I sorted data : 422  grqxb  8347   b
Hi this is thread : 3  and I sorted data : 253  ggcje  2486   c       Hi this is thread : 0  and I sorted data : 489  gtonk  6373   c
Hi this is thread : 3  and I sorted data : 334  gkdik  3955   c       Hi this is thread : 0  and I sorted data : 486  gwyyi  5500   b
Hi this is thread : 3  and I sorted data : 225  glufe  18270  a       Hi this is thread : 0  and I sorted data : 457  hkghn  7702   b
Hi this is thread : 3  and I sorted data : 32   grmve  18309  c       Hi this is thread : 0  and I sorted data : 424  hnzif  9000   a
Hi this is thread : 3  and I sorted data : 407  gxhon  1214   a       Hi this is thread : 0  and I sorted data : 462  hseph  13951  a
Hi this is thread : 3  and I sorted data : 321  gxouy  12341  c       Hi this is thread : 0  and I sorted data : 420  hvbmg  10429  a
Hi this is thread : 3  and I sorted data : 414  hhmfp  9307   d       Hi this is thread : 0  and I sorted data : 482  hvkxr  9847   a
Hi this is thread : 3  and I sorted data : 149  hlslu  14577  d       Hi this is thread : 0  and I sorted data : 453  hzuik  5625   d
Hi this is thread : 3  and I sorted data : 130  hrfbw  11662  b       Hi this is thread : 0  and I sorted data : 426  igaqb  9717   c
Hi this is thread : 3  and I sorted data : 127  hzcff  17278  c       Hi this is thread : 0  and I sorted data : 106  jubmc  11713  a
Hi this is thread : 3  and I sorted data : 382  jfgbm  11800  a       Hi this is thread : 0  and I sorted data : 309  kfuky  10644  d
Hi this is thread : 3  and I sorted data : 274  jidwk  3061   b       Hi this is thread : 0  and I sorted data : 57   khgtp  4289   b
Hi this is thread : 3  and I sorted data : 273  jrruv  8714   b       Hi this is thread : 0  and I sorted data : 116  kueyl  8183   c
Hi this is thread : 3  and I sorted data : 147  junsx  13042  b       Hi this is thread : 0  and I sorted data : 261  lbmde  18388  c
Hi this is thread : 3  and I sorted data : 368  jxvnr  714    b       Hi this is thread : 0  and I sorted data : 500  lhdnm  8558   d
Hi this is thread : 3  and I sorted data : 136  jzunu  452    c       Hi this is thread : 0  and I sorted data : 113  lnaot  10538  d
Hi this is thread : 3  and I sorted data : 146  krfzh  16001  c       Hi this is thread : 0  and I sorted data : 218  logth  5899   b
Hi this is thread : 3  and I sorted data : 100  kxzwk  3143   b       Hi this is thread : 0  and I sorted data : 480  lqfcb  2368   c
Hi this is thread : 3  and I sorted data : 124  lfxzs  11224  b       Hi this is thread : 0  and I sorted data : 245  lrctg  12172  a
Hi this is thread : 3  and I sorted data : 264  lgdqk  10457  d       Hi this is thread : 0  and I sorted data : 228  lxjsj  19077  a
Hi this is thread : 3  and I sorted data : 330  lgrwq  15162  a       Hi this is thread : 0  and I sorted data : 207  lzwxr  2078   a
Hi this is thread : 3  and I sorted data : 313  llvsv  18000  d       Hi this is thread : 0  and I sorted data : 497  mcfbz  17178  d
Hi this is thread : 3  and I sorted data : 181  lphwz  3307   d       Hi this is thread : 0  and I sorted data : 432  mfwll  18068  d
Hi this is thread : 3  and I sorted data : 298  lqyie  12450  d       Hi this is thread : 0  and I sorted data : 229  mgcwp  17676  c
Hi this is thread : 3  and I sorted data : 434  mgmeb  14510  a       Hi this is thread : 0  and I sorted data : 456  mollf  17674  b
Hi this is thread : 3  and I sorted data : 125  mndty  12523  c       Hi this is thread : 0  and I sorted data : 24   mqnox  16106  b
Hi this is thread : 3  and I sorted data : 137  mrlgk  12138  c       Hi this is thread : 0  and I sorted data : 483  mtzyw  8176   a
Hi this is thread : 3  and I sorted data : 123  mslwo  11049  c       Hi this is thread : 0  and I sorted data : 269  mugax  6542   c
Hi this is thread : 3  and I sorted data : 8    mxwhg  361    b       Hi this is thread : 0  and I sorted data : 65   mynms  8886   a
Hi this is thread : 3  and I sorted data : 14   nabfo  366    c       Hi this is thread : 0  and I sorted data : 467  nduds  7317   a
Hi this is thread : 3  and I sorted data : 143  ncntk  8389   a       Hi this is thread : 0  and I sorted data : 458  nmear  4489   b
Hi this is thread : 3  and I sorted data : 208  nfayy  3574   d       Hi this is thread : 0  and I sorted data : 448  nogag  15603  c
```

Snapshots of Output Data (Final Data)

Sorted Data with Name Category

```
135       aaolw    835       c
423       abfqm    17398     c
204       abqom    7419      a
246       adabd    8891      a
476       aduul    9730      d
54        aegyi    9611      c
360       aehtu    10699     b
118       afsmr    14336     c
73        agemc    14100     b
202       ahaie    17436     b
58        ahuei    6350      b
119       aiaxr    18987     c
39        aiqax    1845      b
285       aivfz    997       a
416       aivni    16023     c
91        ajjql    3257      a
338       allzi    5221      b
216       anfsq    6321      b
465       aogqi    19772     d
186       aoldt    16609     b
348       apdsh    14754     c
358       aqsgp    7675      c
262       atlth    11891     c
109       avokj    17398     c
464       awlxx    12613     c
233       awqmo    1306      d
139       aymlk    2520      b
88        baaxp    14399     a
323       baewd    13717     b
295       baksd    9643      b
177       bakzx    9020      d
191       bbcbl    3287      c
195       bgerm    9464      c
174       bgneo    17977     b
236       bhelt    188       c
83        binbm    1689      b
```

Comparison Graph

Time