# Project Report: Database System Implementation (COP6726)
## Project 2 Part 2: Extending DBFile Class
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I have done this project alone without any project partner. Hence, I am submitting it on my behalf.

1) **Compile and Run Instructions:** This program has been compiled, run and tested on Ubuntu 18.04 operating system.

> **Step.1 - Run test.out:**
> In order to run **test.out** first we need to make sure that in test.h file dbfile_dir, tpch_dir and catalog_path is also updated correctly with right locations. please use below commands sequentially and follow onscreen instruction to run **test.out** file.
>
> > > make clean
> > > make test.out
> > > ./test.out
>
> **Step.2 - To run gtest (google tests):**
> In order to run **gtest** first we need to make sure that in "gtest.cc" file dbfile_dir, tpch_dir and catalog_path is also updated correctly with right locations. Pass gtest_arg.txt as argument to run gtests. This file I present in the folder. please use below commands sequentially to run gtest.
>
> > > make clean
> > > make gtest.out
> > >./gtest

2) **Project files, structure, classes and functions:** DBFile is extended and contains following classes.

a) **Generic DBFile Class:** This extended version of DBFile is designed to serve both purposes. Hence it can actually be used for sorted and unsorted both types of heap files. Generic DBFile Class is a generic virtual class which acts as parent class for both the normal heap and sorted DBFile classes. This class contains certain virtual methods which are implemented independently by both children classes. These virtual methods are not common among the children classes hence their implementation is unique in both of the children classes. This class contains protected variables for File, Page, Comparison Engine class objects, it also contains a pointer for preference file. File class objects hold the pages and page class objects hold the records to be written on the disk. There are certain public functions which are common to both of the children classes, these functions are GetPageLocationToWrite() ,GetPageLocationToRead(BufferMode mode) , GetPageLocationToReWrite() , Create (char * f_path,fType f_type, void *startup) and Open (char * f_path). There are other virtual methods which are implemented independently by the children classes these methods are MoveFirst (), Add (), Load (), GenNext (), and Close () methods.

```
class GenericDBFile{
protected:
    //  This file variable is used to conatin pages , page read write operations are done using file
    File fileObj;
    //  Page varibales contains records data
    Page pageObj;
    // this Pointer points to preference file
    Preference * prefPointer;
    // Comparison Engine object variable
    ComparisonEngine comparisonEngineObj;
public:
    GenericDBFile();
    // this Function gets the location to write next page
    int GetPageLocationToWrite();
     // This Function gets the page location from where disk read operation has to be done ,
    //Buffer Mode argument — Will give different locations according to current state of the DBFile.
    int GetPageLocationToRead(BufferMode mode);
    // this function gets the same page location which has to be rewritten
    int GetPageLocationToReWrite();
    void Create (char * f_path,fType fileType, void *startup);
    int Open (char * f_path);

    //  These are virtual function for GenericDBFile
    virtual ~GenericDBFile();
    virtual void MoveFirst ();
    virtual void Add (Record &addme);
    virtual void Load (Schema &myschema, const char *loadpath);
    virtual int GetNext (Record &fetchme);
    virtual int GetNext (Record &fetchme, CNF &cnf, Record &literal);
    virtual int Close();
};
```

**b) HeapDBFile Class:** This class Implements the DBFile unsorted Heap functionality implemented in project. This class contains all the relevant methods which were used to implement unsorted heaps. This class contains a constructor, destructor apart from that There are other virtual methods which are implemented independently by this class these methods are MoveFirst (), Add (), Load (), GenNext (), and Close () methods.

```
//This is Heap DB FIle  Class which inherits and overrides virtual functions from GenericDBFile class
class HeapDBFile: public virtual GenericDBFile{
public:
    HeapDBFile(Preference * preference);
    ~HeapDBFile();
    void MoveFirst ();
    void Add (Record &addme);
    void Load (Schema &myschema, const char *loadpath);
    int GetNext (Record &fetchme);
    int GetNext (Record &fetchme, CNF &cnf, Record &literal);
    int Close ();

};
```

**c) SortedDBFile Class:** This Class contains all the methods which implement the new functionality of sorted heap files. SortedDBFile Class contains attributes such as input and output pipes which can push and retrieve records from the BIgQ class. This class also contains a pointer for BigQ class as well as File object which holds the pages. A buffer attribute is also used in this class which is used before the pages are written into file object. A queryorder maker attribute is used to construct a sort order with given CNF and also sort order of DBFile.

```cpp
class SortedDBFile: public  GenericDBFile{
    Pipe * inputPipePtr;
    Pipe * outputPipePtr;
    BigQ * bigQPtr;
    File newFile;
    Page outputBufferForNewFile;
    OrderMaker * queryOrderMaker;
    bool doBinarySearch;

public:
    SortedDBFile(Preference * preference);
    ~SortedDBFile();
    void MoveFirst ();
    void Add (Record &addme);
    void Load (Schema &myschema, const char *loadpath);
    int GetNext (Record &fetchme);
    int GetNext (Record &fetchme, CNF &cnf, Record &literal);
    int Close ();
    void MergeSortedInputWithFile();
    int BinarySearch(Record &fetchme, Record &literal,off_t low, off_t high);
};
```

**SortedDBFile Class Variables:**

1) **Pipe * inputPipePtr:** This pointer corresponds to a Pipe object. This is an input pipe which is used to write records into BigQ class objects.

2) **Pipe * outputPipePtr:** This pointer corresponds to a Pipe object. This is an output pipe which is used for retrieving records from BigQ class objects.

3) **BigQ * bigQPtr:** This pointer corresponds to BigQ class object. This BigQ class object is used to sort records which are loaded into sorted DBFile Object.

4) **File newFile:** This variable corresponds to file object. A file object is used to store pages. Pages contains records. This file object is specifically used to merge inputs when the mode is changed from write to read.

5) **Page outputBufferForNewFile:** As mentioned above the file object in class is specifically used to merge inputs when the mode is changed from write to read. This **outputBufferForNewFile** variable is a pointer for a Page object which acts as a buffer for writing into file object which is being used to merge inputs. Ultimately this becomes the new sorted DB File in itself.

6) **OrderMaker * queryOrderMaker**: This variable corresponds to order maker object. This query order make is used by GenNext method. This is used to construct a sort order for given CNF and also sort order of DBFile.

7) **bool doBinarySearch:**

**SortedDBFile Class Functions:**

1) **void MoveFirst ()**
   **Description:** MoveFirst () method implementation in DBFile is same as of heap file. In the heap file this function Forces the pointer to reset its position to the first record of the file. Each DBfile constitutes a pointer which points to the first record in the file. This pointer can move with respect to retrievals of records from the file. In a situation where the the page buffer is not empty and the DBFIle is in write mode .Then in that case the non-empty page buffer is first written into dbfile , the first page is read and the first record from the page is fetched.in other conditions the pointer is moved towards first page and it is read.

2) **void Add (Record &addme)**
   **Description**: The class contains an attribute which is an input pipe which is used to write records into BigQ class objects. This Add function is used to write records in the input pipe. Incase if the buffer is set to read mode then before the records are written into pipe the buffer is set to the write mode. Once the buffer is set to write mode then sorted records form the output pipe of BigQ class objects are written into input pipe.

3) **void Load (Schema &myschema, const char *loadpath)**
   **Description:** The load function can add records into input pipe in bulk. Same as add function load function implements the same functionality the only difference is that the load function incorporates a loop to add records in bulk over add function which can only add one record at a time. the loop sucks records from the raw.tbl file, and till all records are not written load function while loop keeps on running.

4) **int GetNext (Record &fetchme)**
   **Description:** This method GetNext() gets records from the dbfiles iteratively. The persistent dbfile (.bin file) contains various pages which in turn contain records. the GetNext() method reads the pages present in the persistant file one by one and fetches all the records present in these pages iteratively.when all the records are read from the file then this function returns 0.

5) **int GetNext (Record &fetchme, CNF &cnf, Record &literal)**
   **Description:** This version of GetNext method takes three arguments. One of the arguments is the CNF predicate. using a function like GetSortOrders of CNF class this given CNF is converted to an OrderMaker object. Then this given CNF is compared with the existing sorting order of dbfile. The attributes of ordermakers can be accommodated with the sort order of DBfile then in that case BinarySearch function is used to find any record that satisfy that CNF. We keep getting such records for each of the subsequent calls to this function.

6) **int Close ()**
   **Description:** This function Close () simply closes the dbfile (.bin file). when the program has completely written the state of dbfile in a .pref file (preference file). the order maker object is also written in the state in the case of sorted DB File. it is done so that the sort order of the file could be known when it is read.

7) **void MergeSortedInputWithFile ()**
   **Description:** When the program switches from write mode to the read mode then this function is used. In this state when the mode is switched then the records wich are already present in the BigQ class object have to be merged with the already sorted file. This function is more of a merge step which merges two sorted sources together. A temporary file is used for writing the merge stream.this temporary file is renamed to original dbfile.

8) **int BinarySearch(Record &fetchme, Record &literal,off_t low, off_t high)**
   **Description:** This function is a function which is used in GetNext() method which also accepts a CNF as an argument. Binary search is applied on the pages of DBFile.The given CNF is compared with the existing sorting order of dbfile. The attributes of ordermakers can be accommodated with the sort order of DBfile then in that case BinarySearch function is used to find any record that satisfy that CNF. This function returns a 0 if no record is found satisfying the CNF.

**3) Program Run Results: All the screenshots are added in screenshots folder of this submission.**

**a) Test Case 1:**

```
[azureuser113@VM-02:~/final/a2-2test$ ./test.out

** IMPORTANT: MAKE SURE THE INFORMATION BELOW IS CORRECT **
 catalog location:      catalog
 tpch files dir:        tpch-dbgen/
 heap files dir:        dbfiles/


 select test option:
        1. create sorted dbfile
        2. scan a dbfile
        3. run some query
[       1

 select table:
        1. nation
        2. region
        3. customer
        4. part
        5. partsupp
        6. supplier
        7. orders
        8. lineitem
[       3

 specify sort ordering (when done press ctrl-D):
[       (c_phone)

 specify runlength:
[       8

 output to dbfile : dbfiles/customer.bin
 input from file : tpch-dbgen/customer.tbl

 select option for : dbfiles/customer.bin
        1. add a few (1 to 1k recs)
        2. add a lot (1k to 1e+06 recs)
        3. run some query
[       2
        .......
        added 150000 recs..so far 150000

 create finished.. 150000 recs inserted


azureuser113@VM-02:~/final/a2-2test$ ▐
```

## b) Test Case 2:

```
[azureuser113@VM-02:~/final/a2-2test$ ./test.out

** IMPORTANT: MAKE SURE THE INFORMATION BELOW IS CORRECT **
   catalog location:     catalog
   tpch files dir:       tpch-dbgen/
   heap files dir:       dbfiles/


   select test option:
          1. create sorted dbfile
          2. scan a dbfile
          3. run some query
          2

   select table:
          1. nation
          2. region
          3. customer
          4. part
          5. partsupp
          6. supplier
          7. orders
          8. lineitem
          3
   scan : dbfiles/customer.bin
          c_custkey: [59986], c_name: [Customer#000059986], c_address: [Ddy7dHn EQi], c_nationkey: [0], c_phone: [10-100-106-1617], c_acctbal: [5956.08], c_mktsegment: [MACHINERY], c_comment: [, even epitaphs wake furiously permanently pending frays. evenly pending accounts
   cajole carefully. pending pack]
   .c_custkey: [42145], c_name: [Customer#000042145], c_address: [HFq56HeXtTnQPOZADDSrr], c_nationkey: [0], c_phone: [10-100-220-4520], c_acctbal: [7128], c_mktsegment: [FURNITURE], c_comment: [ts. Tiresias across the quickly regular f]
   .c_custkey: [86596], c_name: [Customer#000086596], c_address: [nP7P8Oi5MKNIaA2uCVwJ7gg16kCPiO8r,Rj15F9e], c_nationkey: [0], c_phone: [10-100-274-5785], c_acctbal: [6378.16], c_mktsegment: [HOUSEHOLD], c_comment: [thely final accounts haggle slyly. theodolites integrate al
   ongside of ]
   .c_custkey: [127518], c_name: [Customer#000127518], c_address: [Q4Md5pZBiyjq9U41S], c_nationkey: [0], c_phone: [10-100-301-2651], c_acctbal: [6312.45], c_mktsegment: [MACHINERY], c_comment: [even accounts. unusual foxes wake according to the unusual frays. bli]
   .c_custkey: [50984], c_name: [Customer#000050984], c_address: [6rKqT7QOrRmFY71zRTh], c_nationkey: [0], c_phone: [10-100-541-5585], c_acctbal: [6405.08], c_mktsegment: [MACHINERY], c_comment: [even sauternes haggle according to the furiously regular deposits. requests slee
   p]
   .c_custkey: [109996], c_name: [Customer#000109996], c_address: [pACgw87bbHVpU], c_nationkey: [0], c_phone: [10-100-581-8579], c_acctbal: [-611.47], c_mktsegment: [HOUSEHOLD], c_comment: [y even foxes boost carefully carefully ironic packages. bold packages about the blith
   ely unusual depende]
   .c_custkey: [31757], c_name: [Customer#000031757], c_address: [fy7,zGnJjkA39R73O64rL94ljC0rQ0c0W], c_nationkey: [0], c_phone: [10-100-588-9355], c_acctbal: [7731.01], c_mktsegment: [FURNITURE], c_comment: [r deposits? pending ideas sleep furiously. requests ]
   .c_custkey: [81501], c_name: [Customer#000081501], c_address: [kXDhS,iPmUMgA,mKvk], c_nationkey: [0], c_phone: [10-100-864-5796], c_acctbal: [5188.79], c_mktsegment: [BUILDING], c_comment: [sual packages. deposits along the final pinto beans doze stealthily along]
   .c_custkey: [107333], c_name: [Customer#000107333], c_address: [UKH5g9XgF8YIv6j4irOexOy1znw3rF], c_nationkey: [0], c_phone: [10-101-152-4542], c_acctbal: [674.96], c_mktsegment: [MACHINERY], c_comment: [ to the final requests. slyly regular packages at the furiously even
   deposits cajole blithely packages. car]
   .c_custkey: [140521], c_name: [Customer#000140521], c_address: [ uIHEciPqsl4jo6iIhSmAY8belpxufgR0kol], c_nationkey: [0], c_phone: [10-101-162-3523], c_acctbal: [5280.16], c_mktsegment: [FURNITURE], c_comment: [silent requests. regular foxes wake furiously. bli]
   .c_custkey: [96325], c_name: [Customer#000096325], c_address: [GHPGzPiXr9LAJR88KU4sTg3mb7R2ObTU], c_nationkey: [0], c_phone: [10-101-751-3934], c_acctbal: [1054.63], c_mktsegment: [MACHINERY], c_comment: [lar foxes sleep special accounts. regular, pending packag]
   .c_custkey: [29352], c_name: [Customer#000029352], c_address: [n5QpcSIe3jjFGdQtdL4sZL], c_nationkey: [0], c_phone: [10-101-769-8567], c_acctbal: [2538.66], c_mktsegment: [MACHINERY], c_comment: [le blithely carefully regular packages. final]
   .c_custkey: [78599], c_name: [Customer#000078599], c_address: [,JCe4u v rgPuucLDCJoo1WFVIVAMtVQnsau bUw], c_nationkey: [0], c_phone: [10-101-961-1014], c_acctbal: [3636.74], c_mktsegment: [MACHINERY], c_comment: [eposits. final requests run slyly slyly bold deposits. slyl
   y pending deposits around the final, ironic foxes s]
   .c_custkey: [97329], c_name: [Customer#000097329], c_address: [ZcFlwQHNYn], c_nationkey: [0], c_phone: [10-101-970-2347], c_acctbal: [2635.07], c_mktsegment: [HOUSEHOLD], c_comment: [ts. blithely even waters according to the blithely final packages sleep furiously car]
   .c_custkey: [144050], c_name: [Customer#000144050], c_address: [MOfrfVxvkXwW], c_nationkey: [0], c_phone: [10-102-154-7851], c_acctbal: [-963.98], c_mktsegment: [FURNITURE], c_comment: [ven deposits sublate daringly ironic instructions. slyly blithe theodolites are quickl
   y alongside o]
   .c_custkey: [33139], c_name: [Customer#000033139], c_address: [Qyq9nvTJpEyBNB yNzN636Ck7z9zBQ0Mvou], c_nationkey: [0], c_phone: [10-102-409-7401], c_acctbal: [7724.95], c_mktsegment: [BUILDING], c_comment: [n asymptotes. bold instructions sleep carefully. regular excuse]
   .c_custkey: [88036], c_name: [Customer#000088036], c_address: [CJvP0RZ4TpI8i 147DmG61m,2ceQJ8X,], c_nationkey: [0], c_phone: [10-102-549-6244], c_acctbal: [-97.68], c_mktsegment: [AUTOMOBILE], c_comment: [ose furiously ironic accounts. ironic deposits are blithely. ironic
   p]
   .c_custkey: [64573], c_name: [Customer#000064573], c_address: [J0zbtjAen3c yR8], c_nationkey: [0], c_phone: [10-102-554-6504], c_acctbal: [5705.04], c_mktsegment: [AUTOMOBILE], c_comment: [efully ironic braids are. furiously regular deposits use fluffily unusual p]
```

```
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   ironic package]
   .c_custkey: [113698], c_name: [Customer#000113698], c_address: [ IztM8Ghd9aegsYSuQC6w4Sd71WXT8gfF6 eR7], c_nationkey: [24], c_phone: [34-993-166-5163], c_acctbal: [-486.38], c_mktsegment: [HOUSEHOLD], c_comment: [onic ideas are. platelets could have to sleep afte]
   .c_custkey: [126905], c_name: [Customer#000126905], c_address: [bGdhhyN0u,l], c_nationkey: [24], c_phone: [34-993-256-3601], c_acctbal: [7548.42], c_mktsegment: [MACHINERY], c_comment: [ly final instructions about the never even packages print carefully special reques]
   .c_custkey: [29893], c_name: [Customer#000029893], c_address: [GCPC7fmqGFqh4kJhrPInrSwy11qR eV], c_nationkey: [24], c_phone: [34-993-311-3710], c_acctbal: [1260.4], c_mktsegment: [BUILDING], c_comment: [even packages across the unusual instructions use slyly after the reg
   ular, express pinto be]
   .c_custkey: [159993], c_name: [Customer#000159993], c_address: [AK5in1agyfcEP0H1yE0c], c_nationkey: [24], c_phone: [34-993-429-1238], c_acctbal: [7623.36], c_mktsegment: [FURNITURE], c_comment: [ beans are silently stealthy deposits. final instructions cajole final account
   s. quickly final theodolites wake slyl]
   .c_custkey: [144536], c_name: [Customer#000144536], c_address: [4pt4pApv2yN2O3X6dth95Kl], c_nationkey: [24], c_phone: [34-993-667-3229], c_acctbal: [5639.33], c_mktsegment: [HOUSEHOLD], c_comment: [s cajole carefully above the carefully final theodolites. even, regular in
   structions wake ]
   .c_custkey: [46211], c_name: [Customer#000046211], c_address: [gIh5izB0ICv,9], c_nationkey: [24], c_phone: [34-993-926-3853], c_acctbal: [6337.97], c_mktsegment: [MACHINERY], c_comment: [. fluffily special patterns are about the evenly regular grouches. carefully special
   excus]
   .c_custkey: [43757], c_name: [Customer#000043757], c_address: [51efS5RXEYXirEjAK8], c_nationkey: [24], c_phone: [34-994-145-7928], c_acctbal: [-929.94], c_mktsegment: [MACHINERY], c_comment: [ ironic frets wake regularly even asymptotes. regular ideas haggle against the i
   dly pending dugouts; carefully f]
   .c_custkey: [113081], c_name: [Customer#000113081], c_address: [IE0q70P5rYrzoj1 HVk16792Dc4zBaM], c_nationkey: [24], c_phone: [34-994-432-9241], c_acctbal: [5935.36], c_mktsegment: [MACHINERY], c_comment: [ickly ironic excuses wake. unusual, final deposit]
   .c_custkey: [95039], c_name: [Customer#000095039], c_address: [SvniZ1xKo9hq3B0i  99s2NxLlCtrSWB0ZcYz], c_nationkey: [24], c_phone: [34-994-696-2009], c_acctbal: [1071.86], c_mktsegment: [BUILDING], c_comment: [ng, silent foxes try to cajole acr]
   .c_custkey: [126949], c_name: [Customer#000126949], c_address: [hH1qPi9dNuyeYpiTxKt], c_nationkey: [24], c_phone: [34-994-700-9912], c_acctbal: [8610.56], c_mktsegment: [BUILDING], c_comment: [slyly special foxes sleep. carefully unusual requests according to the]
   .c_custkey: [80619], c_name: [Customer#000080619], c_address: [y5kDNj8TNTwz8NTpmw QREn], c_nationkey: [24], c_phone: [34-994-893-6724], c_acctbal: [70.76], c_mktsegment: [FURNITURE], c_comment: [tealthy packages according to the carefully bold accounts are alongside of th
   ]
   .c_custkey: [19768], c_name: [Customer#000019768], c_address: [RG5jiRgUUipTPHx5K3O2vcZpJOX,], c_nationkey: [24], c_phone: [34-995-194-4009], c_acctbal: [5206.51], c_mktsegment: [AUTOMOBILE], c_comment: [nusual requests cajole even, even packages. platelets are slyly. fluf
   fily ironic deposits]
   .c_custkey: [57078], c_name: [Customer#000057078], c_address: [Pq1NVuuNm1Mntx70ha], c_nationkey: [24], c_phone: [34-995-249-6002], c_acctbal: [3861.85], c_mktsegment: [FURNITURE], c_comment: [al epitaphs detect furiously across the regular packages. slyly ironic ]
   .c_custkey: [66195], c_name: [Customer#000066195], c_address: [,YgacKY1JreSU5ldygu1E348MuAnxXayLTuS], c_nationkey: [24], c_phone: [34-995-870-2299], c_acctbal: [5186.45], c_mktsegment: [FURNITURE], c_comment: [furiously pending theodolites sleep after th]
   .c_custkey: [74263], c_name: [Customer#000074263], c_address: [88KuJXq4Ab1nXGOnJ,Sot6 ,ommnxsDyGVYOJf], c_nationkey: [24], c_phone: [34-995-950-2170], c_acctbal: [7803.79], c_mktsegment: [MACHINERY], c_comment: [unts impress. slyly final foxes haggle carefully around the
   unusua]
   .c_custkey: [88858], c_name: [Customer#000088858], c_address: [1Mshbshapj], c_nationkey: [24], c_phone: [34-996-605-1799], c_acctbal: [6066.8], c_mktsegment: [AUTOMOBILE], c_comment: [theodolites after the fluffily pending theodolites boost bold accounts. furiously regula
   r orbits cajole regularl]
   .c_custkey: [139443], c_name: [Customer#000139443], c_address: [26MgKUkBcs,SP LtunUm3VV3O,bvyaJv2HBOM], c_nationkey: [24], c_phone: [34-996-663-4478], c_acctbal: [-395.28], c_mktsegment: [BUILDING], c_comment: [olphins integrate blithely carefully pending pinto beans. pen
   ding pl]
   .c_custkey: [37326], c_name: [Customer#000037326], c_address: [DQK3cxIC7H29vd5kLTHoh0kHOPjfUUS], c_nationkey: [24], c_phone: [34-996-695-7639], c_acctbal: [3155.24], c_mktsegment: [HOUSEHOLD], c_comment: [inal accounts sleep slyly regular pains. c]
   .c_custkey: [25985], c_name: [Customer#000025985], c_address: [m wW1OO AZTfsAYbRctOZDAoUe], c_nationkey: [24], c_phone: [34-996-827-5819], c_acctbal: [6393.05], c_mktsegment: [BUILDING], c_comment: [sly across the blithely even deposits. slyly pending excuses nag slyly. p
   ackages ]
   .c_custkey: [6048], c_name: [Customer#000006048], c_address: [DNtLkGdov3MnFfAGa40Pi6c6Y1r5j NF], c_nationkey: [24], c_phone: [34-996-904-3634], c_acctbal: [2634.46], c_mktsegment: [AUTOMOBILE], c_comment: [ sleep blithely across the regular deposits. accounts wake. slyly
   ironic gifts above th]
   .c_custkey: [2068], c_name: [Customer#000002068], c_address: [q3hQ8nHhhsJ2n], c_nationkey: [24], c_phone: [34-996-986-1652], c_acctbal: [-839.34], c_mktsegment: [HOUSEHOLD], c_comment: [ the closely express excuses wake furiously furiously special requ]
   .c_custkey: [101355], c_name: [Customer#000101355], c_address: [sJStaX901FOW], c_nationkey: [24], c_phone: [34-997-188-9666], c_acctbal: [32.59], c_mktsegment: [FURNITURE], c_comment: [even sheaves wake quickly expr]
   .c_custkey: [37088], c_name: [Customer#000037088], c_address: [I2kfDo3fodNGYonS0MJsS], c_nationkey: [24], c_phone: [34-997-204-5897], c_acctbal: [2484.13], c_mktsegment: [AUTOMOBILE], c_comment: [al theodolites haggle across the quickly ir]
   .c_custkey: [3174], c_name: [Customer#000003174], c_address: [9XGPFKLWZMU], c_nationkey: [24], c_phone: [34-997-244-3200], c_acctbal: [6117.29], c_mktsegment: [BUILDING], c_comment: [round the furiously express packages. furiously regular courts are furio]
   .c_custkey: [86364], c_name: [Customer#000086364], c_address: [vMKeNm EzZa75U3vkmI2Rnp0jC9], c_nationkey: [24], c_phone: [34-997-251-4190], c_acctbal: [2691.67], c_mktsegment: [AUTOMOBILE], c_comment: [ even foxes haggle quickly blithely regular pinto beans. slyly regular
   ideas sleep slyly along the f]
   .c_custkey: [35286], c_name: [Customer#000035286], c_address: [ P  HN6QXTmlBpJ5Xps], c_nationkey: [24], c_phone: [34-997-517-4660], c_acctbal: [120.81], c_mktsegment: [AUTOMOBILE], c_comment: [und the permanent packages sleep blithely according to the special, even request
   s. express foxes ]
   .c_custkey: [48253], c_name: [Customer#000048253], c_address: [gAVusA09FVBERzgQoz S1Qc9wYkO7gYX1TLRkG], c_nationkey: [24], c_phone: [34-997-697-4316], c_acctbal: [4429.09], c_mktsegment: [AUTOMOBILE], c_comment: [express forges use after the carefully ironic ideas. slyly
   express foxes sleep quickly. carefully special]
   .c_custkey: [31537], c_name: [Customer#000031537], c_address: [82Fr5r7gWxt2a5], c_nationkey: [24], c_phone: [34-998-190-8709], c_acctbal: [-252.7], c_mktsegment: [HOUSEHOLD], c_comment: [ructions cajole ideas. slyly express depos]
   .c_custkey: [117513], c_name: [Customer#000117513], c_address: [cuBZ TE0EONnPFmoOdv6EIHxKU43AV], c_nationkey: [24], c_phone: [34-998-315-4817], c_acctbal: [2334.66], c_mktsegment: [AUTOMOBILE], c_comment: [c ideas are. accounts haggle agains]
   .c_custkey: [53730], c_name: [Customer#000053730], c_address: [6fv7IW9Pr91QntCZzwsi1e2GXOxJj9A ], c_nationkey: [24], c_phone: [34-998-382-6518], c_acctbal: [4923.4], c_mktsegment: [MACHINERY], c_comment: [ silent requests haggle carefully regular, regular packages. entici
   ng, even deposits wake slyly among the]
   .c_custkey: [12022], c_name: [Customer#000012022], c_address: [PwVDMfqZtKWOo], c_nationkey: [24], c_phone: [34-998-408-4382], c_acctbal: [2877.36], c_mktsegment: [HOUSEHOLD], c_comment: [layers. regular pinto beans about the quickly regular ideas cajole blithely]
   .c_custkey: [125210], c_name: [Customer#000125210], c_address: [B3iJAg79TvSTdxgPeb63sUqKaOVv], c_nationkey: [24], c_phone: [34-998-711-2597], c_acctbal: [6678.32], c_mktsegment: [FURNITURE], c_comment: [ly ironic, ironic accounts. theodolites among the slyly even patterns
   nag slyly fluffi]
   .c_custkey: [50667], c_name: [Customer#000050667], c_address: [9aGxwCYLcG6y2eA], c_nationkey: [24], c_phone: [34-999-115-2195], c_acctbal: [8764.52], c_mktsegment: [FURNITURE], c_comment: [mptotes around the slyly bold instructions boost furi]
   .c_custkey: [7288], c_name: [Customer#000007288], c_address: [,dZCqJe94SqXQjxAd7WxRMYyFVKGd4pFIrAshk], c_nationkey: [24], c_phone: [34-999-121-7718], c_acctbal: [82.07], c_mktsegment: [HOUSEHOLD], c_comment: [ns sublate furiously. carefully ironic platelets grow furiously
   . ironic, bold theodolites hang above th]
   .c_custkey: [84642], c_name: [Customer#000084642], c_address: [MJerprOnUYRK], c_nationkey: [24], c_phone: [34-999-195-7029], c_acctbal: [6912.63], c_mktsegment: [BUILDING], c_comment: [totes above the pending, regular hockey players sleep blithely after the blithely even
   deposits. carefully regula]
   .c_custkey: [148611], c_name: [Customer#000148611], c_address: [HoNNKAELd2vMNyGWpw3ZZgSNaDs7fOdNIH64], c_nationkey: [24], c_phone: [34-999-283-6448], c_acctbal: [24.12], c_mktsegment: [HOUSEHOLD], c_comment: [requests above the blithely pending asymptotes sleep carefully
   about the slyly even excu]
   .c_custkey: [102689], c_name: [Customer#000102689], c_address: [uPFxngvSOaDQIL], c_nationkey: [24], c_phone: [34-999-363-7145], c_acctbal: [6256.97], c_mktsegment: [AUTOMOBILE], c_comment: [ly regular asymptotes haggle fluffily according to the furiously bold courts. dari
   ng ]
   .c_custkey: [35478], c_name: [Customer#000035478], c_address: [Ot5zcyiiLhzXXivX4Y2FeToQIh,iovs6zyA], c_nationkey: [24], c_phone: [34-999-379-6016], c_acctbal: [6097.18], c_mktsegment: [MACHINERY], c_comment: [ithout the fluffily ironic packages. daring, even de]
   .c_custkey: [103505], c_name: [Customer#000103505], c_address: [XPNXpdCD7HRqcV8ABpjF3ixDc9A6X ZB2 ], c_nationkey: [24], c_phone: [34-999-404-9770], c_acctbal: [582.88], c_mktsegment: [FURNITURE], c_comment: [fully even deposits boost. quickly ironic requests could have to
   are according to the final accounts. final]
   .c_custkey: [62707], c_name: [Customer#000062707], c_address: [bRbtSTIXhh], c_nationkey: [24], c_phone: [34-999-473-9448], c_acctbal: [7429.32], c_mktsegment: [FURNITURE], c_comment: [zzle slyly after the slyly ironic pinto beans. bold, fina]
   .c_custkey: [41774], c_name: [Customer#000041774], c_address: [DphfJFKVkr4LQeif9t5SSKzDUa4G3asKeya5M7dz], c_nationkey: [24], c_phone: [34-999-535-1203], c_acctbal: [7118.29], c_mktsegment: [FURNITURE], c_comment: [ requests sleep. quickly silent requests wake fluffily. f
   uriously close packages nag furiously across the caref]
   .c_custkey: [94308], c_name: [Customer#000094308], c_address: [5aE9PLelngeVq8v6KCgQyR,NhDT5uC4], c_nationkey: [24], c_phone: [34-999-618-6653], c_acctbal: [8636.13], c_mktsegment: [FURNITURE], c_comment: [g, even deposits. carefully unus]
   .c_custkey: [102414], c_name: [Customer#000102414], c_address: [Xzg9eiWbsxiQW,LUCyUAcPoOENdLUQt], c_nationkey: [24], c_phone: [34-999-618-6881], c_acctbal: [9614.62], c_mktsegment: [MACHINERY], c_comment: [usly final packages. carefully even packages by the permanently sp
   ecial gifts ne]

   scanned 150000 recs


azureuser113@VM-02:~/final/a2-2test$ ▯
```

## c) Test Case 3:

```
[azureuser113@VM-02:~/final/a2-2test$ ./test.out

** IMPORTANT: MAKE SURE THE INFORMATION BELOW IS CORRECT **
 catalog location:      catalog
 tpch files dir:        tpch-dbgen/
 heap files dir:        dbfiles/


 select test option:
        1. create sorted dbfile
        2. scan a dbfile
        3. run some query
        3

 select table:
        1. nation
        2. region
        3. customer
        4. part
        5. partsupp
        6. supplier
        7. orders
        8. lineitem
        3

 enter CNF predicate (when done press ctrl-D):
        (c_phone > '34-999-195-7029') AND (c_mktsegment = 'FURNITURE')

        c_custkey: [103505], c_name: [Customer#000103505], c_address: [XPNXpdCD7HRqcV8ABpjF3ixDc9A6X ZB2 ], c_nationkey: [24], c_phone: [34-999-404-9770], c_acctbal: [582.88], c_mktsegment: [FURNITURE], c_comment: [fully even deposits boost. quickly ironic requests could
have to are according to the final accounts. final]
c_custkey: [62707], c_name: [Customer#000062707], c_address: [bRbtSTIXhh], c_nationkey: [24], c_phone: [34-999-473-9448], c_acctbal: [7429.32], c_mktsegment: [FURNITURE], c_comment: [zzle slyly after the slyly ironic pinto beans. bold, fina]
c_custkey: [41774], c_name: [Customer#000041774], c_address: [DpHfJFKVkr4LQeif9t5SSKzDUa4G3asKeya5M7dz], c_nationkey: [24], c_phone: [34-999-535-1203], c_acctbal: [7118.29], c_mktsegment: [FURNITURE], c_comment: [c requests sleep. quickly silent requests wake fluffily. fu
riously close packages nag furiously across the caref]
c_custkey: [94308], c_name: [Customer#000094308], c_address: [5aE9PLelngeVg8v6KCgOyR,NhDT5uC4], c_nationkey: [24], c_phone: [34-999-618-6653], c_acctbal: [8636.13], c_mktsegment: [FURNITURE], c_comment: [g, even deposits. carefully unus]

 query over dbfiles/customer.bin returned 4 recs

azureuser113@VM-02:~/final/a2-2test$
```

## d) Gtest Results:

```
[azureuser113@VM-02:~/final/a2-2test$ ./gtest
[==========] Running 1 test from 1 test suite.
[----------] Global test environment set-up.
[----------] 1 test from testingLoadSortedFile
[ RUN      ] testingLoadSortedFile.testingLoadSortedFile
[       OK ] testingLoadSortedFile.testingLoadSortedFile (0 ms)
[----------] 1 test from testingLoadSortedFile (0 ms total)

[----------] Global test environment tear-down
[==========] 1 test from 1 test suite ran. (0 ms total)
[  PASSED  ] 1 test.
azureuser113@VM-02:~/final/a2-2test$
```