2019 B+ tree implementation assignment

Course name: Database Systems (ITE2038)

Professor: Sang-Wook Kim (email: wook@agape.hanyang.ac.kr)

TAs: Taeri Kim (email: taerik@agape.hanyang.ac.kr)
Dong-Hyuk Seo (email: hyuk125@agape.hanyang.ac.kr)

1. Assignment Title

- Implementation of a B+ tree index

2. Environment

- OS: Windows
- Language: Java or Python (any version is ok)

3. Constraints – Overall

- The B+ tree index should be stored in a single file (index file)
- The file contains all the meta information for the index and also the index nodes
- The internal organization of the file is not considered in grading
- The program should provide following functions:
  - ■ Search
    - ✓ A single key search AND a range search
  - ■ Insertion of a key
  - ■ Deletion of a key
    - ✓ The deleted entry should be completely removed from the index and the file
- Assumption
  - ■ Keys and values are all in the integer type
  - ■ Duplicated keys are not allowed for insertions
  - ■ The keys in a node are stored in an ASCENDING order
- POLICY on COPY • DO NOT COPY someone else's program
  - ■ DO NOT USE functions/methods/routines from existing code/library/programs in pre-implemented B+ tree indexes or any other similar tree-based indexes
  - ■ All these actions are regarded as COPY and so will be handled accordingly

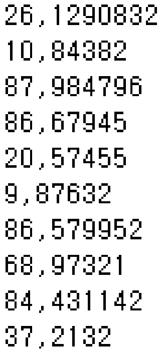
4. Constraints – Internal Structure

- Each node of a B+ tree index should contain the following data inside:
  - ■ Non-leaf node
    - ✓ *m*: # of keys
    - ✓ *p*: an array of b <*key, left_child_node*> pairs
    - ✓ *r*: a pointer to the rightmost child node
  - ■ Leaf node
    - ✓ *m*: # of keys

        - ✓ *p*: an array of b *<key, value(or pointer to the value)>* pairs
        - ✓ *r*: a pointer to the right sibling node

5. Constraints – Interface

- The program *should support* ***command-line interface***
- The following commands should be implemented:
    - Data File Creation
        - ✓ Command: *program -c index_file b*
            - *program*: name of the program (bptree)
            - *index_file*: name of a new index file
            - *b*: size of each node (max. # of child nodes)
        - ✓ This command creates a new index file containing an empty index with node size *b*
            - If the file already exists, it is overwritten
        - ✓ Example
            - java bptree -c index.dat 8
    - Insertion
        - ✓ Command: program -i *index_file data_file*
            - *data_file*: name of the input data file that has a number of key-value pairs to be inserted
        - ✓ This command inserts all the key-value pairs inside the data_file into the index in the index_file
            - The insertion causes the modification of the index file
            - Insertions are performed in the same order of key-value pairs in the data file
        - ✓ The data file is provided as a .csv file (Comma Separated Values)
            - Each line of the data file contains a key-value pair
                - <key>,<value>\n
            - Data file example (input.csv)

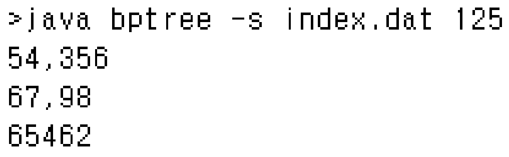


```
26,1290832
10,84382
87,984796
86,67945
20,57455
9,87632
86,579952
68,97321
84,431142
37,2132
```

        - ✓ Example
            - java bptree -i index.dat input.csv
    - Deletion
        - ✓ Command: *program -d index_file data_file*
            - *data_file*: name of the input data file that has a number of keys to be deleted

    - This command deletes all the key−value pairs inside the input data file from the index
        - The deletion causes the modification of the index file
        - Deletions are performed in the same order of keys in the data file
    - The input data file is provided as a .csv file (Comma Separated Values)
        - Each line of the data file contains only a key value
            - <key>\n
    - Example
        - java bptree −d index.dat delete.csv

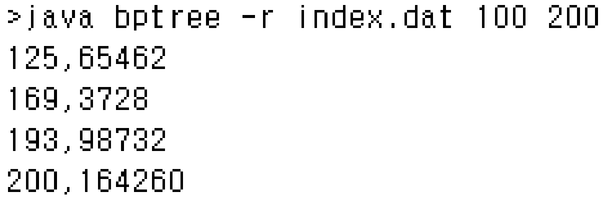
- Single Key Search
  - Command: *program −s index_file key*
    - *key*: key value to be searched
  - This command returns a value of a pointer to a record with the key
  - Output format
    - Print output to the *stdout*
    - While searching, the program prints each non−leaf node in the path that the search passes through
      - Print all the keys in the node in a single line
      - <key1>,<key2>,□,<keym>\n
    - When the search reaches the leaf node having the search key, print the value matched with the search key
      - <value>\n
      - If not found, print □NOT FOUND□
    - Example
      - java bptree −s index.dat 125



```
>java bptree -s index.dat 125
54,356
67,98
65462
```

- Ranged Search
  - Command: *program −r index_file start_key end_key*
    - *start_key*: lower bound of the range search
    - *end_key*: upper bound of the ranged search
  - This command returns the values of pointers to records having the keys within the range provided
  - Output format
    - Print output to the *stdout*
    - Print all the key−value pairs with the key between *start_key* and *end_key* (including start_key and end_key)
      - <key1>,<value1>\n<key2>,<value2>\n□
    - Note that *start_key* and *end_key* may not be in the index
      - The program prints only the key−value pairs between them
  - Example

- ✓ java bptree –r index.dat 100 200



```
>java bptree -r index.dat 100 200
125,65462
169,3728
193,98732
200,164260
```

6. How to turn in

(1) Write your program

(2) Write a document (.doc, .docx, or .pdf) that contains:

- Summary of your algorithm
- Detailed description of your codes (for each function)
- Instructions for compiling your source codes at TA's computer (e.g. screenshot) (Important!!)
  - You MUST SUBMIT instructions for compiling your source codes. If TAs read your instructions but cannot compile your program, you will get a penalty Please, write the instructions carefully
- Any other specification of your implementation and testing

(3) Zip the codes and the document

- The filename should follow the format
  - B–tree_Assignment_<YOUR_STUDENT_NUMBER>.zip
  - Ex.) B–tree_Assignment_2010051924.zip
- The zip file should contain a executable file, all source files, and the document

(4) Submit it to gitlab (http://hconnect.hanyang.ac.kr/)

- Due date

Completed before 25 September:	100%
Completed before 2 October:	70%
After 2 October:	0%

You can ask questions about the assignment via class community and/or e–mail
YOU WILL GET SERIOUS PENALTIES IF YOU DO COPY OR CHEAT

Good luck!