2022 B+ tree implementation assignment

Course name: Database Systems (ITE2038)

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1. Assignment Title

- Implementation of a B+ tree index

2. Environment

- OS: Windows or mac os
- Language: Java or Python (any version is ok)
  - C++ language is also allowed, but not recommended

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 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

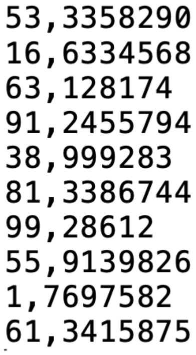
4. Constraints - Internal Structure

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

5. Constraints - Interface

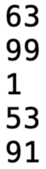
- The program *should support **command-line interface***
- The following commands should be implemented:
    - Data File Creation
        - ✓ Command: *program -c index_file b*
            - ➢ *program*: name of the program (bptree)
            - ➢ *index_file*: name of a new index file
            - ➢ *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)



```
53,3358290
16,6334568
63,128174
91,2455794
38,999283
81,3386744
99,28612
55,9139826
1,7697582
61,3415875
```

    - ✓ 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
        - Deletion file example (delete.csv)



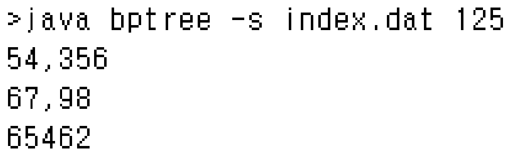
```
63
99
1
53
91
```

    - ✓ 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

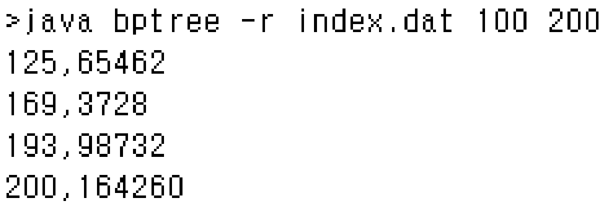
            - Print all the keys in the node in a single line
            - <key1>,<key2>,...,<keym>₩n

        - 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 (This is not the same dataset as above 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) Register our course git lab and make repository named 'B-tree_Assignment'

(2) Clone git lab repository to your PC

(3) Write your program

(4) Write a document (pdf file) 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

(5) Put what you wrote in the repository

- Repository should contain an executable file, all source files, and the document
  - If you use python, there is no need to contain an executable file.
- The file structure is as follows
  - B-tree_Assignment₩

```
      Source₩
            {Your source files}.java/.py₩
      {Your executable file}.exe/.jar
      {Your document}.pdf
```

(6) Push it to the **git lab**

- **Due date**
  - **Completed before 23 September: 100%**
  - **Completed before 30 September: 70%**
  - **After 30 September: 0%**

You can ask questions about the assignment via Piazza(announced later) community.

YOU WILL GET SERIOUS PENALTIES IF YOU DO COPY OR CHEAT

Good luck!