2020 B+ tree implementation assignment

1. Assignment Title

- Implementation of a B+ tree index

2. Environment

- OS: Windows or mac os
- 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 <u>AND</u> 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 <u>ASCENDING order</u>
- 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
```

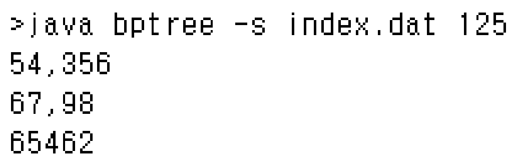
  - ✓ Example
    - java bptree -d index.dat delete.csv

- 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

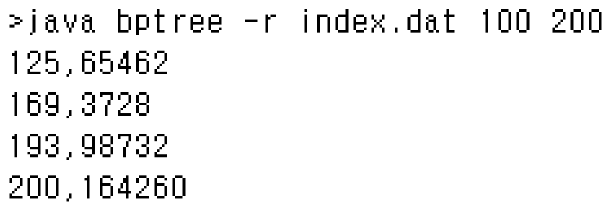
- Print all the keys in the node in a single line
- <key1>,<key2>,…,<keym>₩n

- 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
```