2017 B+ tree implementation assignment

Course name: Data Science (ITE4005)

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

TAs: Jangwan Koo (email: koojwan@dake.hanyang.ac.kr)
Tae-Ri Kim (email: taerik@dake.hanyang.ac.kr)
Yeon-Chang Lee (email: lyc0324@dake.hanyang.ac.kr)

1. Assignment Title

- Implementation of a B+ tree index

2. Environment

- OS: Windows
- Language: Java

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** 범위 검색 지원
    - ✓ 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 ~~pointers~~ 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 오름차순
- **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 children 자식의 수
    - ✓ *p*: an array of b *<key, left_child_node>* pairs key, 왼쪽 노드 포인터
    - ✓ *r*: a pointer to the rightmost child node 가장 오른쪽 자식 노드
  - Leaf node
    - ✓ *m*: # of ~~children~~ keys
    - ✓ *p*: an array of b *<key, value(or pointer to the value)>* pairs
    - ✓ *r*: a pointer to the right sibling node 형제 노드

5. Constraints - Interface

- The program *should support* ***command-line interface*** 명령어 지원
- 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) 가질 수 있는 자식 노드의 최대값
    - ✓ 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 or .docx) that contains (in English):

- 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 (.exe), all source files, and the document

(4) Submit it to the class community (http://portal.hanyang.ac.kr/)

- Due date
  - Completed before 7 September: 130%
  - Completed before 14 September: 100%
  - Completed before 21 September: 70%
  - After 21 September: 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!