[Database system Assignment 3]

Index B+tree

컴퓨터소프트웨어

2015005141 최연수

1. 개발환경

Mac terminal version 2.9.5

Docker version 19.03.2

2. 사용언어

C++

3. 코드 설명

```
    RC InsertNode(const void* aKey, const RID & aRid);
    RC DeleteNode(const void* aKey, int kpos);
    RC MergeNode(IX_BTNode* aNode);
    RC SplitNode(IX_BTNode* aNewNode);
    RC DistributeNode(IX_BTNode* aLeftNode);
```

(ix.h)

ix.h 파일에 새로 만든 DistributeNode 함수를 추가로 선언해준다.

```
/*-----------------------------------------------------------*/

RC IX_BTNode::DistributeNode(IX_BTNode * aLeftNode) {

    if (keysNum > order) return -1; //fail

    RID rid = *(rids);
    void * k;
    GetKey(0, k);
    RC rc = aLeftNode->InsertNode(k, rid);
    if (rc != 0) return rc;

    void * keytodel;
    GetKey(0, keytodel);
    rc = DeleteNode(keytodel, -1);
    if (rc == -1) return rc;

    return OK_RC;
}
/*-----------------------------------------------------------*/
```

(ix_btnode.cc)

Ix_btnode.cc 파일에 DistributeNode 함수의 내용을 작성해준다.

함수에서 distribute하고자 하는 값 (이하, X) 의 왼쪽 노드를 인자로 받는다.

X를 왼쪽 노드에 InsertNode 해 준 이후 원래 노드에 있던 X를 DeleteNode 해준다.

```
RC IX_IndexHandle::InsertEntry(void *pData, const RID &rid, int detail) {
    RC invalid = IsValid();
    if (invalid) return invalid;

    if (pData == NULL) return IX_BADKEY;

    bool newLargest = false;
    void * prevKey = NULL;
    int level = fileHdr.height - 1;

    IX_BTNode* node = FindLeaf(pData);
    IX_BTNode* newNode = NULL;
    assert(node != NULL);

    /*-----------------------------------------------------*/
    IX_BTNode* leftNode = FetchNode(node->GetLeft());

    if(node->GetKeysNum() == node->GetMaxKeys()){
        if(leftNode != NULL){
            IX_BTNode * nodeParent = path[level-1];

            FindLeaf(leftNode->LargestKey());
            IX_BTNode * nodeParentL = path[level-1];

            int posParentL = pathP[level-1];

            FindLeaf(pData);

            if(nodeParentL == nodeParent){
                if(leftNode->GetKeysNum() < leftNode->GetMaxKeys()){

                    node->DistributeNode(leftNode);
                    nodeParent->DeleteNode(NULL, posParentL);
                    nodeParent->InsertNode(leftNode->LargestKey(), leftNode->GetNodeRID());
                }
            }
        }
    }
    delete leftNode;
    /*-----------------------------------------------------*/
```

(ix_indexhandle.cc)

Ix_indexHandle.cc 에서 InsertEntry 부분에 distribute 과정을 추가해준다.

우선 찾은 pData (위의 X)가 들어있는 노드 (이하, N)의 현재 key 개수와, N이 포함할 수 있는

최대 key의 개수를 비교한다.(첫번째 if문).

개수가 같아 distribute 해야 될 상황이라면 N의 왼쪽 노드가 존재하는지 확인한다.(두번째 if문)

왼쪽 노드가 존재한다면, N과 그 왼쪽 노드의 부모가 같은지 확인을 하는데 (세번째 if문),

이 때, path가 변경이 되기 때문에, 각각을 nodeParentL 과 posParentL에 저장해준다. 이후, 왼쪽 노드가

현재 가지고 있는 key 수와 최대 가질 수 있는 key수를 비교하고(네번째 if문), 이를 만족한다면 DistributeNode함수를 이용하여 pData를 왼쪽 노드로 옮겨준다.

왼쪽 노드의 max값이 부모 노드에 들어가야하므로, 이전 이들의 부모 값을 지우고, 새로운 max값을 insert해준다.

4. 실행과정

4.1 distribution 이전

```
root@62efdb4e0c5c:/home/edubase/src# ./ix_test
Starting IX component test.

Test 1: create, open, close, delete an index...
IX_CreatIndex test OK!
IX_OpenIndex test OK!
IX_CloseIndex test OK!
Doing "ls -l *testrel*"
-rw------- 1 root root  12288 Dec 21 05:28 testrel.0
-rw-rw-r-- 1 1001 1001   8192 Apr 21  2014 testrel.10
-rw-rw-r-- 1 1001 1001 139264 Apr 21  2014 testrel.25
Passed Test 1

Test2: Insert a few integer entries into an index...
            Adding 20 int entries
Verifying index contents
Verifying index contents
State:Index is open.
Index Root Page number:1
Index Smallest Page number:1
Index #Pages:2
Index BTNode order:340
Index B+ Tree Height:1
Doing "ls -l *testrel*"
-rw------- 1 root root  12288 Dec 21 05:28 testrel.0
-rw-rw-r-- 1 1001 1001   8192 Apr 21  2014 testrel.10
-rw-rw-r-- 1 1001 1001 139264 Apr 21  2014 testrel.25
Passed Test 2

Test3: Delete many integer entries from an index...
            Adding 57971 int entries
root split happened
root split happened
State:Index is open.
Index Root Page number:344
Index Smallest Page number:1
Index #Pages:345
Index BTNode order:340
Index B+ Tree Height:3
Verifying index contents
Verifying index contents
*****************After Deleteing*****************
        Deleting 46376 int entries
        100%
State:Index is open.
Index Root Page number:344
Index Smallest Page number:274
Index #Pages:72
Index BTNode order:340
Index B+ Tree Height:3
Verifying index contents
Verifying index contents
Doing "ls -l *testrel*"
-rw------- 1 root root 1417216 Dec 21 05:29 testrel.0
-rw-rw-r-- 1 1001 1001    8192 Apr 21  2014 testrel.10
-rw-rw-r-- 1 1001 1001  139264 Apr 21  2014 testrel.25
Passed Test 3
```

```
Test4: Inequality scans...
insert finir.........
insert finir.........
            Adding 57971 int entries
root split happened
root split happened
insert finir.........
open less than scan for 28985.........
Found 28984 entries in <-scan.
open less equal scan for 28985.........
Found 28985 entries in <=-scan.
open larger than scan for 28985.........
Found 28986 entries in >-scan.
Found 28987 entries in >=-scan.
Doing "ls -l *testrel*"
-rw------- 1 root root 1417216 Dec 21 05:29 testrel.0
-rw-rw-r-- 1 1001 1001    8192 Apr 21  2014 testrel.10
-rw-rw-r-- 1 1001 1001  139264 Apr 21  2014 testrel.25
Passed Test 4

Test5: Insert a large integer entries into an index...
            Adding 57971 int entries
root split happened
root split happened
State:Index is open.
Index Root Page number:344
Index Smallest Page number:1
Index #Pages:345
Index BTNode order:340
Index B+ Tree Height:3
Verifying index contents
Verifying index contents
Doing "ls -l *testrel*"
-rw------- 1 root root 1417216 Dec 21 05:29 testrel.0
-rw-rw-r-- 1 1001 1001    8192 Apr 21  2014 testrel.10
-rw-rw-r-- 1 1001 1001  139264 Apr 21  2014 testrel.25
Passed Test 5

Test6: Insert a large float entries into an index...
            Adding 57971 float entries
        0%    root split happened
        99%    root split happened
        100%
Doing "ls -l *testrel*"
-rw------- 1 root root 1417216 Dec 21 05:29 testrel.0
-rw-rw-r-- 1 1001 1001    8192 Apr 21  2014 testrel.10
-rw-rw-r-- 1 1001 1001  139264 Apr 21  2014 testrel.25
Passed Test 6
```

```
Test7: Insert a large String entries into an index...
            Adding 57971 string entries
        0%    root split happened
        99%    root split happened
        100%
Doing "ls -l *testrel*"
-rw------- 1 root root 1417216 Dec 21 05:29 testrel.0
-rw-rw-r-- 1 1001 1001    8192 Apr 21  2014 testrel.10
-rw-rw-r-- 1 1001 1001  139264 Apr 21  2014 testrel.25
Passed Test 7

Ending IX component test.
```

4.2 distribution 이후

```
root@62efdb4e0c5c:/home/edubase/src# ./ix_test
Starting IX component test.

Test 1: create, open, close, delete an index...
IX_CreatIndex test OK!
IX_OpenIndex test OK!
IX_CloseIndex test OK!
Doing "ls -l *testrel*"
-rw------- 1 root root     12288 Dec 22 01:08 testrel.0
-rw-r--r-- 1  501 dialout   8192 Apr 21  2014 testrel.10
-rw-r--r-- 1  501 dialout 139264 Apr 21  2014 testrel.25
Passed Test 1

Test2: Insert a few integer entries into an index...
            Adding 20 int entries
Verifying index contents
Verifying index contents
State:Index is open.
Index Root Page number:1
Index Smallest Page number:1
Index #Pages:2
Index BTNode order:340
Index B+ Tree Height:1
Doing "ls -l *testrel*"
-rw------- 1 root root     12288 Dec 22 01:08 testrel.0
-rw-r--r-- 1  501 dialout   8192 Apr 21  2014 testrel.10
-rw-r--r-- 1  501 dialout 139264 Apr 21  2014 testrel.25
Passed Test 2

Test3: Delete many integer entries from an index...
            Adding 57971 int entries
root split happened
State:Index is open.
Index Root Page number:3
Index Smallest Page number:1
Index #Pages:173
Index BTNode order:340
Index B+ Tree Height:2
Verifying index contents
Verifying index contents
*****************After Deleteing*****************
        Deleting 46376 int entries
        100%
State:Index is open.
Index Root Page number:3
Index Smallest Page number:138
Index #Pages:37
Index BTNode order:340
Index B+ Tree Height:2
Verifying index contents
Verifying index contents
Doing "ls -l *testrel*"
-rw------- 1 root root    712704 Dec 22 01:08 testrel.0
-rw-r--r-- 1  501 dialout   8192 Apr 21  2014 testrel.10
-rw-r--r-- 1  501 dialout 139264 Apr 21  2014 testrel.25
Passed Test 3
```

```
Test4: Inequality scans...
insert finir.........
insert finir.........
             Adding 57971 int entries
root split happened
insert finir.........
open less than scan for 28985.........
Found 28984 entries in <-scan.
open less equal scan for 28985.........
Found 28985 entries in <=-scan.
open larger than scan for 28985.........
Found 28986 entries in >-scan.
Found 28987 entries in >=-scan.
Doing "ls -l *testrel*"
-rw------- 1 root root    712704 Dec 22 01:08 testrel.0
-rw-r--r-- 1  501 dialout   8192 Apr 21  2014 testrel.10
-rw-r--r-- 1  501 dialout 139264 Apr 21  2014 testrel.25
Passed Test 4

Test5: Insert a large integer entries into an index...
             Adding 57971 int entries
root split happened
State:Index is open.
Index Root Page number:3
Index Smallest Page number:1
Index #Pages:173
Index BTNode order:340
Index B+ Tree Height:2
Verifying index contents
Verifying index contents
Doing "ls -l *testrel*"
-rw------- 1 root root    712704 Dec 22 01:08 testrel.0
-rw-r--r-- 1  501 dialout   8192 Apr 21  2014 testrel.10
-rw-r--r-- 1  501 dialout 139264 Apr 21  2014 testrel.25
Passed Test 5

Test6: Insert a large float entries into an index...
             Adding 57971 float entries
        0%    root split happened
        100%
Doing "ls -l *testrel*"
-rw------- 1 root root    712704 Dec 22 01:08 testrel.0
-rw-r--r-- 1  501 dialout   8192 Apr 21  2014 testrel.10
-rw-r--r-- 1  501 dialout 139264 Apr 21  2014 testrel.25
Passed Test 6

Test7: Insert a large String entries into an index...
             Adding 57971 string entries
        0%    root split happened
        1%    root split happened
        100%
Doing "ls -l *testrel*"
-rw------- 1 root root    1404928 Dec 22 01:08 testrel.0
-rw-r--r-- 1  501 dialout    8192 Apr 21  2014 testrel.10
-rw-r--r-- 1  501 dialout  139264 Apr 21  2014 testrel.25
Passed Test 7


Ending IX component test.
```

Distribute 수행 이후에, root split이 적게 일어나고, tree의 높이가 더 낮은 것을 확인할 수 있다.