화일처리 보고서 B-Tree 삭제

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강의 슬라이드를 참조하였습니다.

출력 결과 1

output.txt

```
Processing
B-Tree
  File
M = 3
Delete 66
Delete 10
Delete 22
Delete 30
Delete 44
Delete 55
Delete 50
Delete 60
Delete 100
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Delete 18
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```
M = 4
Delete 66
 Delete 10
 Delete 22
 Delete 30
 Delete 44
 Delete 55
 Delete 50
 Delete 60
 Delete 100
 Delete 28
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 Delete 9
 Delete 5
 Delete 17
 Delete 6
 Delete 3
 Delete 1
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2 소스 코드

```
#include <iostream>
   #include <vector>
   #include <stack>
   #include <algorithm>
   using namespace std;
   enum FLAG {LEFT, RIGHT, MERGE};
   class BTreeNode {
   public:
10
        BTreeNode(int key) {
11
            keys.push_back(key);
12
            childs.assign(2, nullptr);
13
14
        }
15
        BTreeNode(const BTreeNode *node) : n(node->n), keys(node->keys), childs(node->childs) {}
16
        ~BTreeNode() {
17
            for (auto child: childs) delete child;
18
        void insertKey(int newKey, BTreeNode *newChild=nullptr, int newChildPos=RIGHT) {
20
            keys.push_back(newKey);
21
            childs.push_back(newChild);
22
            int i = ++n - 1;
            while (i > 0 \&\& keys[i] < keys[i-1]) {
24
                swap(keys[i], keys[i-1]);
                swap(childs[i], childs[i+1]);
26
                i--;
28
            if (newChildPos == LEFT) swap(childs[i], childs[i+1]);
        }
30
31
        bool deleteKey(int oldKey, int oldChildPos=RIGHT) {
32
            int i = 0;
33
            while (i < n && oldKey > keys[i]) i++;
            if (keys[i] != oldKey) return false;
35
            keys.erase(keys.begin() + i);
36
            if (oldChildPos == RIGHT) i++;
37
            childs.erase(childs.begin() + i);
            n--;
39
            return true;
        }
41
        int n = 0;
43
        vector<int> keys;
        vector<BTreeNode*> childs;
45
        static int M;
46
   };
47
   int BTreeNode::M = 3;
49
50
   bool insertBT(BTreeNode *&T, int newKey) {
51
        if (T == nullptr) {
52
            T = new BTreeNode(newKey);
53
            return true;
54
```

```
}
55
         stack<BTreeNode*> st;
56
         BTreeNode *x = T;
57
         while (x != nullptr) {
58
             int i = 0;
59
             while (i < x->n && newKey > x->keys[i]) i++;
60
             if (i < x->n && newKey == x->keys[i]) return false;
             st.push(x);
62
             x = x \rightarrow childs[i];
63
         }
64
         BTreeNode *newChild = nullptr;
66
         while (true) {
67
             x = st.top(); st.pop();
68
             x->insertKey(newKey, newChild);
             if (x->n < BTreeNode::M) break;</pre>
70
             newKey = x->keys[x->n/2];
             newChild = new BTreeNode(x);
72
             x \rightarrow keys.resize(x \rightarrow n/2);
73
             x \rightarrow childs.resize(x \rightarrow n/2+1);
74
             x->n /= 2;
75
             newChild->keys.erase(newChild->keys.begin(), newChild->keys.begin() + newChild->n/2+1);
76
             newChild->childs.erase(newChild->childs.begin(), newChild->childs.begin() + newChild->n/2+1);
77
             newChild->n -= newChild->n / 2 + 1;
78
             if (st.empty()) {
79
                  T = new BTreeNode(newKey);
                  T \rightarrow childs[0] = x;
81
                  T->childs[1] = newChild;
                  break;
83
             }
         }
85
         return true;
87
    }
89
    bool deleteBT(BTreeNode *&T, int oldKey) {
90
         stack<BTreeNode*> st;
91
         BTreeNode *x = T;
92
         while (x != nullptr) {
93
             int i = 0;
94
             while (i < x->n && oldKey > x->keys[i]) i++;
             if (i < x->n \&\& oldKey == x->keys[i]) break;
96
             st.push(x);
97
             x = x->childs[i];
98
         }
99
         if (x == nullptr) return false; // Search Fail
100
         if (x->childs[0] != nullptr) { // if x is Internal Node
101
             BTreeNode *internalNode = x;
102
             st.push(x);
             x = x-> childs[find(x->keys.begin(), x->keys.end(), oldKey) - x->keys.begin()+1];
104
105
             while (x != nullptr) {
                  st.push(x);
106
                  x = x - > childs[0];
107
             }
108
             x = st.top(); st.pop();
109
             *find(internalNode->keys.begin(), internalNode->keys.end(), oldKey) = x->keys[0];
110
```

```
x->keys[0] = oldKey;
111
        }
112
        x->deleteKey(oldKey);
113
        BTreeNode *y, *leftSibling, *rightSibling;
114
        while (x->n < (BTreeNode::M+1)/2-1 && !st.empty()) { // While Underflow
115
            y = st.top(); st.pop();
116
            int idx = find(y->childs.begin(), y->childs.end(), x) - y->childs.begin();
117
            if (x == y->childs[0]) leftSibling = nullptr;
118
            else leftSibling = y->childs[idx-1];
119
            if (x == y->childs.back()) rightSibling = nullptr;
120
            else rightSibling = y->childs[idx+1];
            int flag;
122
            if (leftSibling == nullptr || rightSibling == nullptr) {
123
                 if (leftSibling == nullptr) {
124
                     if (rightSibling->n > (BTreeNode::M-1)/2) flag = RIGHT;
                     else flag = MERGE;
126
                 }
                 else {
128
                     if (leftSibling->n > (BTreeNode::M-1)/2) flag = LEFT;
129
                     else flag = MERGE;
130
                 }
131
            }
132
            else {
133
                 if (leftSibling->n >= rightSibling->n && leftSibling->n > (BTreeNode::M-1)/2) flag = LEFT;
134
                 else if (rightSibling->n > leftSibling->n) flag = RIGHT;
135
                 else flag = MERGE;
137
            if (flag == LEFT) { // Get key from left sibling
                 x->insertKey(y->keys[idx-1], leftSibling->childs.back(), LEFT);
139
                 y->keys[idx-1] = leftSibling->keys.back();
                 leftSibling->deleteKey(leftSibling->keys.back());
141
            }
            else if (flag == RIGHT) { // Get key from right sibling
143
                 x->insertKey(y->keys[idx], rightSibling->childs[0], RIGHT);
                 y->keys[idx] = rightSibling->keys[0];
145
                 rightSibling->deleteKey(rightSibling->keys[0], LEFT);
146
            }
147
            else { // Merge
148
                 if (leftSibling == nullptr) {
149
                     idx++;
150
                     leftSibling = x;
                     x = rightSibling;
152
                 }
153
                 leftSibling->keys.push_back(y->keys[idx-1]);
154
                 leftSibling->n++;
155
                 y->deleteKey(y->keys[idx-1], RIGHT);
156
                 leftSibling->keys.insert(leftSibling->keys.end(), x->keys.begin(), x->keys.end());
157
                 leftSibling->childs.insert(leftSibling->childs.end(), x->childs.begin(), x->childs.end());
158
                 leftSibling->n += x->n;
                 x->childs.clear();
160
161
                 delete x;
            }
162
            x = y;
163
164
        if (T->n == 0) {
165
            y = T;
166
```

```
T = T -> childs[0];
167
             y->childs.clear();
168
             delete y;
169
170
171
         return true;
172
    }
173
174
    void inorderBT(BTreeNode *T) {
175
         if (T == nullptr) return;
176
         for (int i=0;i<T->n;++i) {
177
             inorderBT(T->childs[i]);
178
             cout << T->keys[i] << ' ';
179
180
         inorderBT(T->childs[T->n]);
181
    }
182
183
    int main() {
184
         cout << " File Processing " << endl;</pre>
185
                         B-Tree" << endl;
186
         cout << "======== << endl;
187
188
         int insertKeys[] = {
189
             40, 11, 77, 33, 20, 90, 99, 70, 88, 80,
190
             66, 10, 22, 30, 44, 55, 50, 60, 100, 28,
191
             18, 9, 5, 17, 6, 3, 1, 4, 2, 7,
192
             8, 73, 12, 13, 14, 16, 15, 25, 24, 28,
193
             45, 49, 42, 43, 41, 47, 48, 46, 63, 68,
194
             61, 62, 64, 69, 67, 65, 54, 59, 58, 51,
195
             53, 57, 52, 56, 83, 81, 82, 84, 75, 89
196
         };
197
198
         int deleteKeys[] = {
199
             66, 10, 22, 30, 44, 55, 50, 60, 100, 28,
200
             18, 9, 5, 17, 6, 3, 1, 4, 2, 7,
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             8, 73, 12, 13, 14, 16, 15, 25, 24, 28,
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205
             61, 62, 64, 69, 67, 65, 54, 59, 58, 51
206
         };
207
208
         BTreeNode *root = nullptr;
209
210
         BTreeNode::M = 3;
211
         cout << "M = 3" << endl;
212
         for (int key : insertKeys) insertBT(root, key);
213
214
         for (int key : deleteKeys) {
215
             cout << "Delete " << key << '\t';</pre>
216
             deleteBT(root, key);
217
             inorderBT(root);
218
             cout << endl;</pre>
219
220
221
         delete root;
222
```

```
root = nullptr;
223
224
         cout << "========" << endl;</pre>
225
         BTreeNode::M = 4;
226
         cout << "M = 4" << endl;
227
         for (int key : insertKeys) insertBT(root, key);
228
229
         for (int key : deleteKeys) {
230
             cout << "Delete " << key << '\t';</pre>
231
             deleteBT(root, key);
232
             inorderBT(root);
             cout << endl;</pre>
234
         }
235
236
         delete root;
238
         return 0;
239
    }
240
```