1. **Some definition**
   o <u>Direct-permission</u> is a permission that user has directly
   o <u>Indirect-permission</u> is a permission that user has because he manages other user who has this permission
   o <u>Full-permissions</u> of user is all of direct-permissions and indirect-permissions
   o <u>Direct-staff</u> of user is staff that user manages directly

2. **Algorithm**
   o **Step 1: Read number of users, permissions from buffer and assign for each user**
      ▪ Read number of users: N
      ▪ Read permissions for CEO from input buffer, add permissions to CEO. The permissions are direct-permissions of CEO
      ▪ Read N lines from input buffer, for X-th line:
         ✓ Add permissions to user X. The permissions are direct-permissions of user X

   o **Step 2: Read and assign manager, staffs for each user**
      ▪ Read N lines from input buffer, for X-th line:
         ✓ If data is string **CEO**:
            ❖ Set -1 for CEO's manager
            ❖ Add user X to list direct-staffs of CEO
         ✓ If data is number, assume Y, Y is manager of user X
            ❖ Set Y for user X's manger
            ❖ Add user XX to list direct-staffs of user Y

   o **Step 3**: Add full permissions (direct-permissions and indirect-permissions) for each user, using Depth First Search (DFS) algorithm, beginning from CEO.
      ▪ Add full-permissions (direct-permissions + indirect permissions) for all users using DFS.
   o **Step 4: Write output result to writer buffer for Question 1**
      ▪ Get full-permissions from user to write

   o **Step 5**: Process command and update permissions for user.
      ▪ Read remain lines from input buffer, for each line:
         ✓ if data is string of format **ADD X Y**:
            ▪ Add <u>*direct-permission Y*</u> to user X
            ▪ Add <u>*indirect-permission Y*</u> to all user X's managers (using DFS)
         ✓ if data is string of format **QUERY X**:
            ▪ Print permissions of user X to output buffer
         ✓ if data is string of format **REMOVE X Y**
            ▪ Remove a <u>*direct-permission Y*</u> from user X
            ▪ Remove <u>*indirect-permission Y*</u> from all user X's managers (using DFS)

3. **Complexity of algorithm**
   o Time complexity
      ▪ $O(N * K)$

- Space complexity
  - O (N*K)