Introduction to Data Structures

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Homework 3C

- 10 points for coding evaluation
  - Submission format
    - File name: yourid_HW3C.c
      - Example: 2000123456_HW3C.c
    - File type: .c (NOT .cpp)
  - Submission site: https://icampus.skku.edu
    - Week 9: [Homework] 3C (code)

- No report

- Due date
  - 11/10 23:59 (no late submission accepted)

Rules for homework

- You should follow instructions.
  - Complier
    - You will get no/less point if your program cannot be complied with the specified complier
  - Input/output format
    - You will get no/less point if TA's automatic evaluation program cannot parse your input or output.
  - Permitted modification scope
    - You will get no/less point if you modify code outside of the permitted modification scope
  - All other rules
    - You will get severe penalty or no/less point if you violate the given rules.

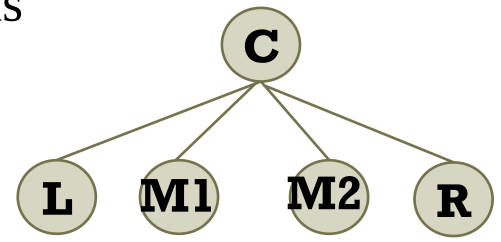
Complier and input/output rules for homework

- Every implementation homework will be evaluated by TA's automatic evaluation program with the following complier.
  - Complier: GCC 7.X, 8.X, 9.X or 10.X
    - https://gcc.gnu.org/
  - You will get no/less point if your program cannot be complied with GCC 7.X, 8.X, 9.X or 10.X.
    - For example, do not rely on visual studio.
  - You can use standard library such as *stdlib.h* and *math.h*.

- Input/output format
  - You will get no/less point if TA's automatic evaluation program cannot parse your input or output according to the following rules.
  - Use `stdin` and `stdout`

Problem

- Problem: QuadTree implementation using linked list
  - QuadTreeNode consists of left, middle1, middle2 and right tree.
  - Implement QuadTreeNode and its basic operations
    - You can use your coding of Homework 3B.
  - Implement level-order traversal.

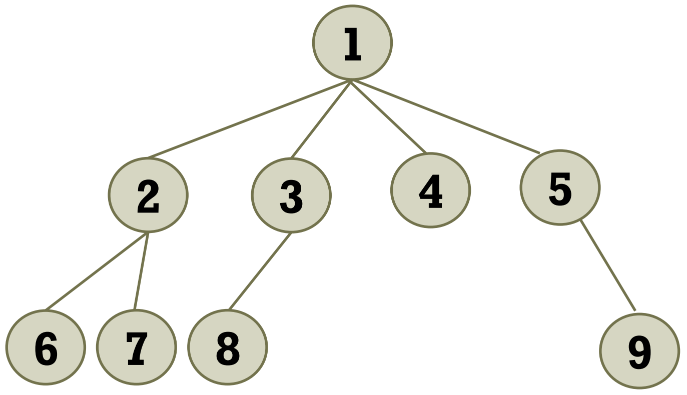


Output

- Output

```
1: 2 3 4 5
2: 6 7 null null
3: 8 null null null
4: null null null null
5: null null null 9
6: null null null null
7: null null null null
8: null null null null
9: null null null null
1 2 3 4 5 6 7 8 9
```

$\dashrightarrow$ Level-order



Template

- You have a template.

```c
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
/* Modify from here */


/* Modify to here */


typedef int QuadData;

typedef struct _QuadTreeNode {
        QuadData item;
        struct _QuadTreeNode *left_child;
        struct _QuadTreeNode *middle1_child;
        struct _QuadTreeNode *middle2_child;
        struct _QuadTreeNode *right_child;
} QuadTreeNode;

void PrintTreeNode(QuadTreeNode *node);

QuadTreeNode *CreateNode(QuadData item);
void DestroyNode(QuadTreeNode *node);
void CreateLeftSubtree(QuadTreeNode *root, QuadTreeNode *left);
void CreateMiddle1Subtree(QuadTreeNode *root, QuadTreeNode *middle1);
void CreateMiddle2Subtree(QuadTreeNode *root, QuadTreeNode *middle2);
void CreateRightSubtree(QuadTreeNode *root, QuadTreeNode *right);
void levelorder(QuadTreeNode *root);
QuadTreeNode *leftMost(QuadTreeNode* node);

/* Modify from here */


/* Modify to here */


int main() {
        QuadTreeNode *node1 = CreateNode(1);
        QuadTreeNode *node2 = CreateNode(2);
        QuadTreeNode *node3 = CreateNode(3);
        QuadTreeNode *node4 = CreateNode(4);
        QuadTreeNode *node5 = CreateNode(5);
```

```c
        CreateLeftSubtree(node1, node2);
        CreateMiddle1Subtree(node1, node3);
        CreateMiddle2Subtree(node1, node4);
        CreateRightSubtree(node1, node5);

        CreateLeftSubtree(node2, node6);
        CreateMiddle1Subtree(node2, node7);

        CreateLeftSubtree(node3, node8);
        CreateRightSubtree(node5, node9);


        PrintTreeNode(node1);
        PrintTreeNode(node2);
        PrintTreeNode(node3);
        PrintTreeNode(node4);
        PrintTreeNode(node5);
        PrintTreeNode(node6);
        PrintTreeNode(node7);
        PrintTreeNode(node8);
        PrintTreeNode(node9);

        levelorder(node1);

        DestroyNode(node1);
        DestroyNode(node2);
        DestroyNode(node3);
        DestroyNode(node4);
        DestroyNode(node5);
        DestroyNode(node6);
        DestroyNode(node7);
        DestroyNode(node8);
        DestroyNode(node9);

        return 0;
}
```

Template

- You have a template.

```
void PrintTreeNode(QuadTreeNode *node) {
        printf("%d: ", node->item);
        node->left_child == NULL ? printf("null ") : printf("%d ", node->left_child->item);
        node->middle1_child == NULL ? printf("null ") : printf("%d ", node->middle1_child->item);
        node->middle2_child == NULL ? printf("null ") : printf("%d ", node->middle2_child->item);
        node->right_child == NULL ? printf("null\n") : printf("%d\n", node->right_child->item);
}

QuadTreeNode *leftMost(QuadTreeNode* node) {
  if (node==NULL) return NULL;
  while (node->left_child != NULL || node->middle1_child != NULL) {
    if (node->left_child != NULL) node = node->left_child;
    else if (node->middle1_child != NULL) node = node->middle1_child;
  }
  return node;
}


/* Modify from here */


/* Modify to here */
```

Template

- You cannot modify the template except the space between /*Modify from here*/ and /*Modify to here*/
  - Do not remove /*Modify from here*/ and /*Modify to here*/
  - TA will copy the space and evaluate your code.
  - You may add user-defined functions and header files between /*Modify from here*/ and /*Modify to here*/.
  - In the space, you need to implement the following functions. (Next page)

Template

- QuadTreeNode *CreateNode(QuadData item);
  - Create a QuadTreeNode with item
- void DestroyNode(QuadTreeNode *node);
  - Free the memory space of node
- void CreateLeftSubtree(QuadTreeNode *root, QuadTreeNode *left);
  - Attach the node of left as left_child of the node of root
- void CreateMiddle1Subtree(QuadTreeNode *root, QuadTreeNode *middle1);
  - Attach the node of middle1 as middle1_child of the node of root
- void CreateMiddle2Subtree(QuadTreeNode *root, QuadTreeNode *middle2);
  - Attach the node of middle2 as middle2_child of the node of root
- void CreateRightSubtree(QuadTreeNode *root, QuadTreeNode *right);
  - Attach the node of right as right_child of the node of root

Template

- void levelorder(QuadTreeNode *root);
  - Traverse and print nodes using levelorder starting from the root node

Evaluation

- Evaluation
  - TA will test several cases by changing the main function.
  - Read Pages 7~9 (regarding template) carefully.
  - For each test case,
    - If your C code results in an answer within 10 seconds on a platform with average computing power,
      - If your output is perfect
        - You get 100%.
    - Else,
      - You get 0%.