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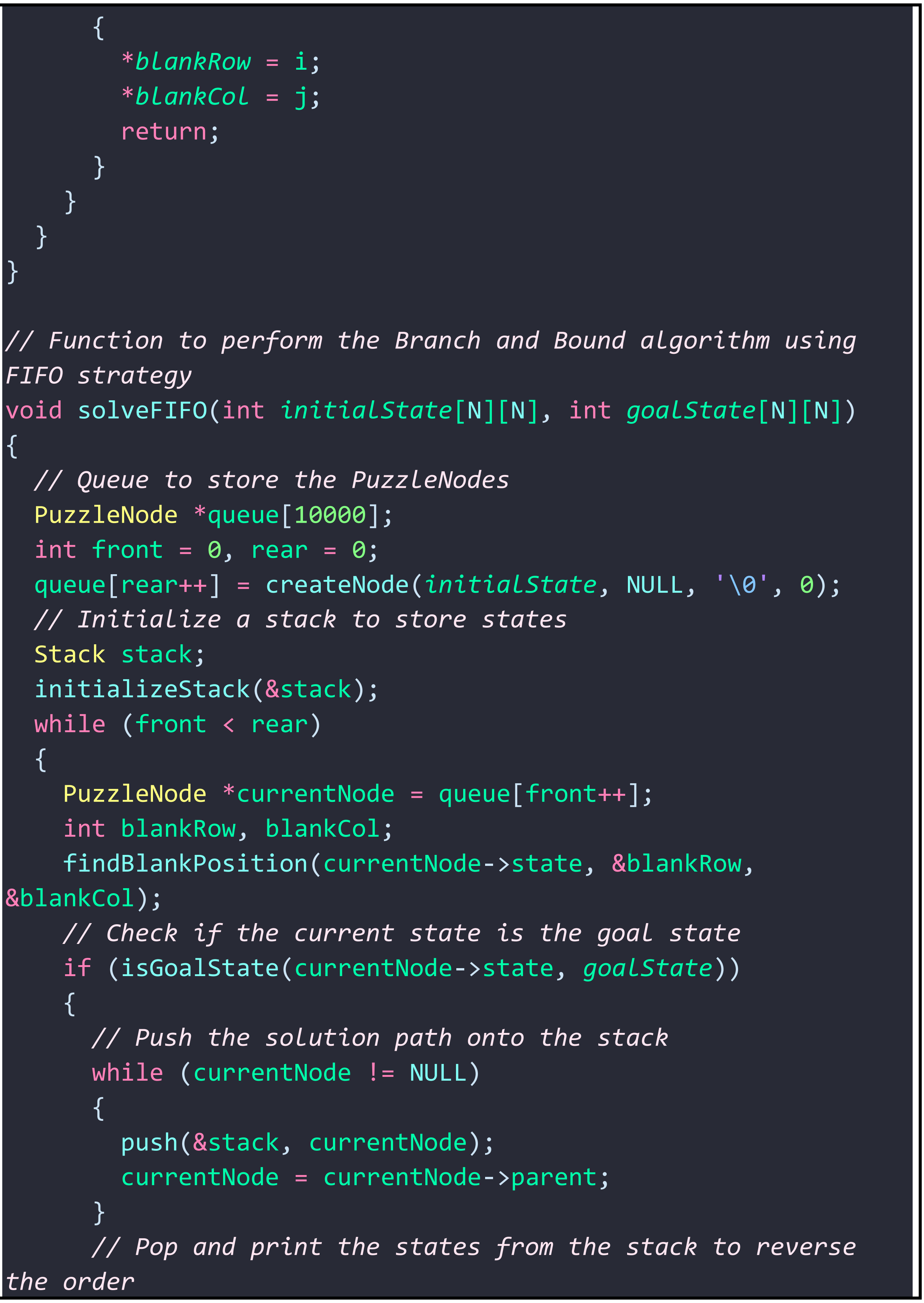
Subject	Design and Analysis of Algorithms (DAA)
Experiment No.	9
Aim	To implement Branch and Bound (FIFO and LC).

Code:

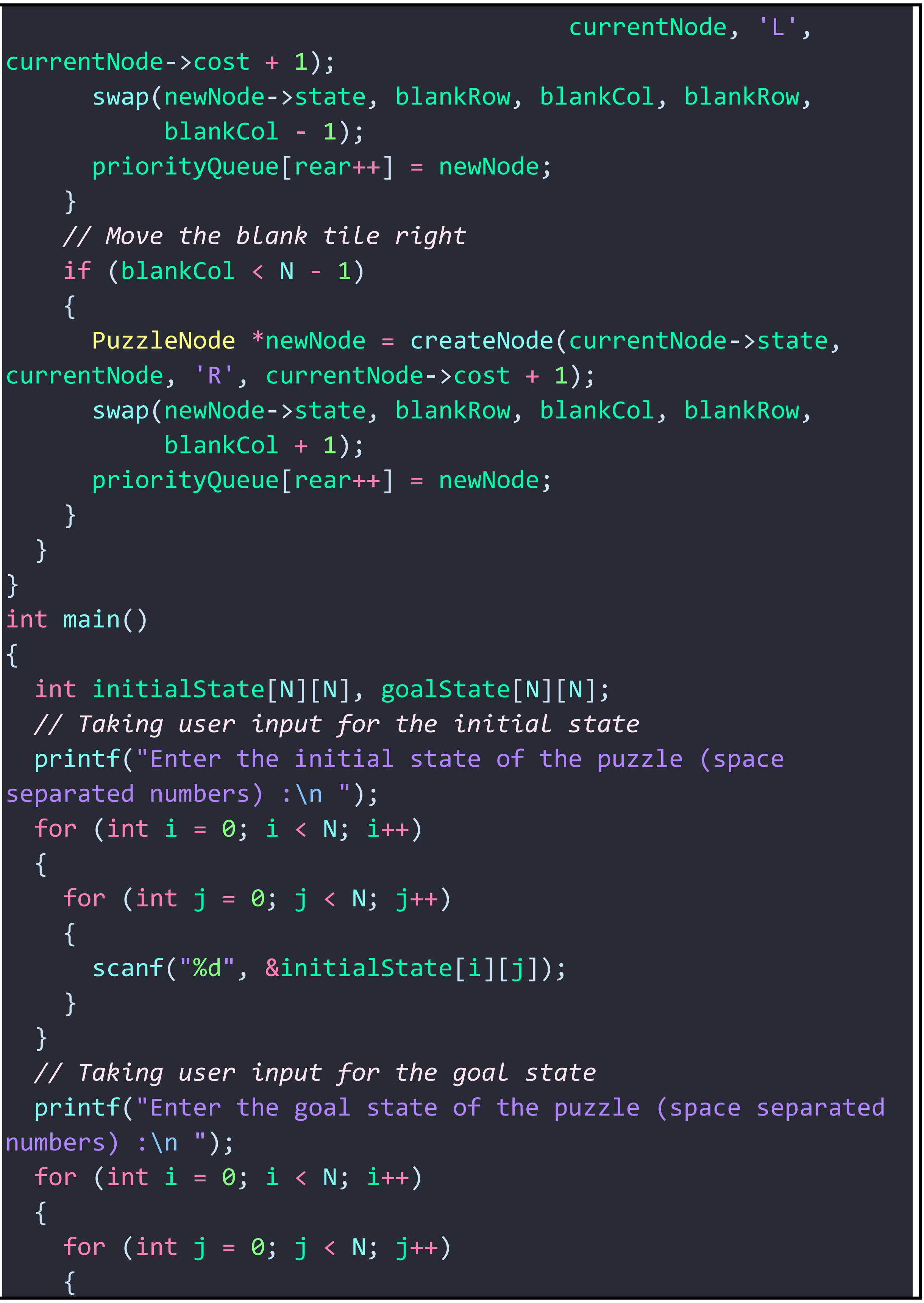
```c
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>
#define N 4
typedef struct PuzzleNode
{
  int state[N][N];
  struct PuzzleNode *parent;
  char action;
  int cost;
} PuzzleNode;
// Define a stack structure for storing states
typedef struct Stack
{
  PuzzleNode *items[10000];
  int top;
} Stack;
// Function to initialize the stack
void initializeStack(Stack *stack)
{
  stack->top = -1;
}
// Function to push an item onto the stack
void push(Stack *stack, PuzzleNode *item)
{
  stack->items[++stack->top] = item;
}
// Function to pop an item from the stack
```

```
PuzzleNode *pop(Stack *stack)
{
  return stack->items[stack->top--];
}
// Function to create a new PuzzleNode
PuzzleNode *createNode(int state[N][N], PuzzleNode *parent,
char action, int cost)
{
  PuzzleNode *newNode = (PuzzleNode
*)malloc(sizeof(PuzzleNode));
  if (newNode == NULL)
  {
    printf("Memory allocation failed.\n");
    exit(1);
  }
  for (int i = 0; i < N; i++)
  {
    for (int j = 0; j < N; j++)
    {
      newNode->state[i][j] = state[i][j];
    }
  }
  newNode->parent = parent;
  newNode->action = action;
  newNode->cost = cost;
  return newNode;
}
// Function to check if the current state is the goal state
bool isGoalState(int state[N][N], int goalState[N][N])
{
  for (int i = 0; i < N; i++)
  {
    for (int j = 0; j < N; j++)
    {
      if (state[i][j] != goalState[i][j])
      {
        return false;
      }
    }
  }
  return true;
}
// Function to print the state of the puzzle
void printState(int state[N][N])
{
  for (int i = 0; i < N; i++)
  {
    for (int j = 0; j < N; j++)
    {
      printf("%d ", state[i][j]);
    }
    printf("\n");
  }
  printf("\n");
}

// Function to swap two tiles in the state matrix
void swap(int state[N][N], int i1, int j1, int i2, int j2)
{
  int temp = state[i1][j1];
  state[i1][j1] = state[i2][j2];
  state[i2][j2] = temp;
}

// Function to find the position of the blank tile in the
state matrix
void findBlankPosition(int state[N][N], int *blankRow, int
*blankCol)
{
  for (int i = 0; i < N; i++)
  {
    for (int j = 0; j < N; j++)
    {
      if (state[i][j] == 0)
```

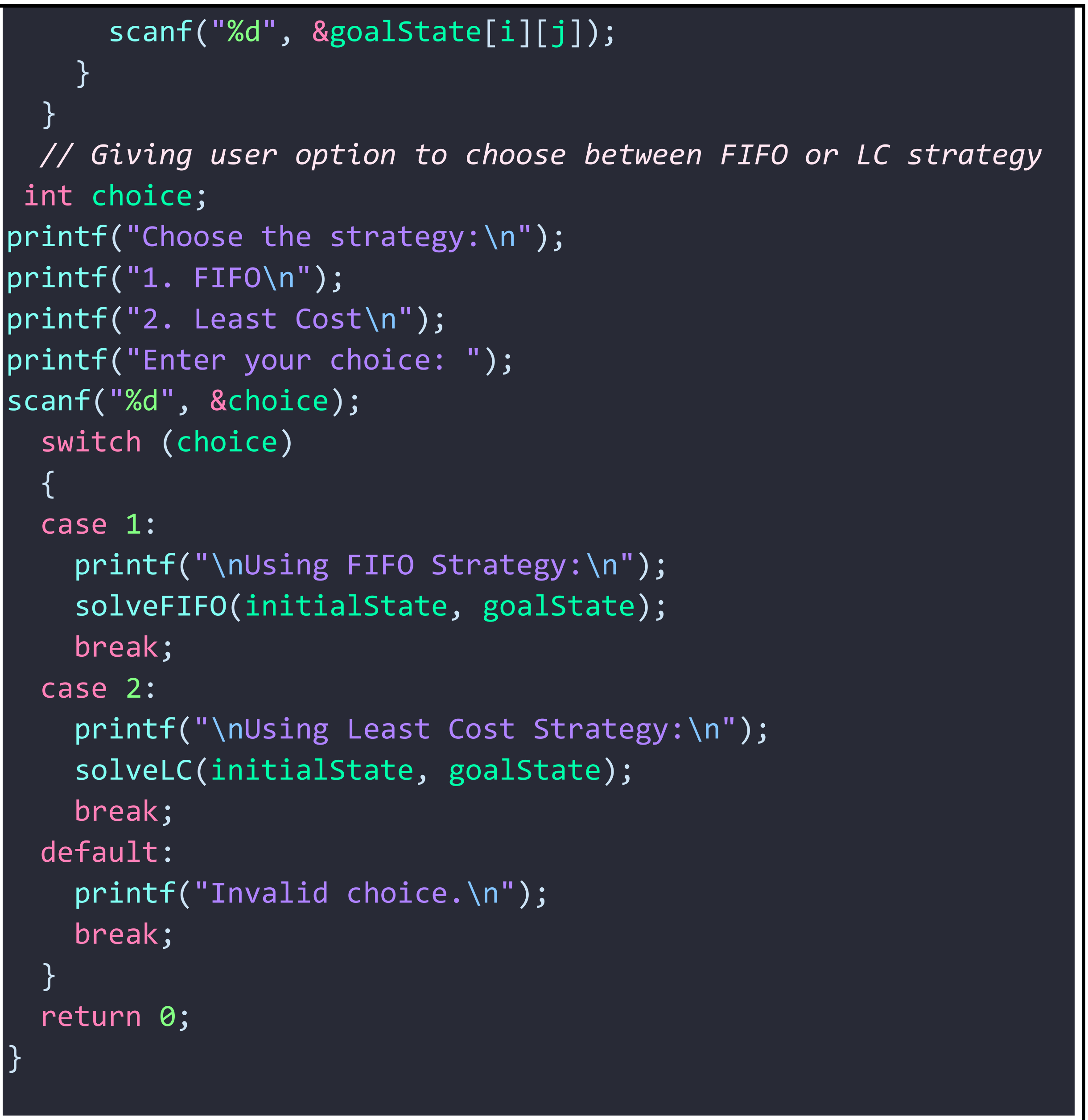


```
      {
        *blankRow = i;
        *blankCol = j;
        return;
      }
    }
  }
}

// Function to perform the Branch and Bound algorithm using
FIFO strategy
void solveFIFO(int initialState[N][N], int goalState[N][N])
{
  // Queue to store the PuzzleNodes
  PuzzleNode *queue[10000];
  int front = 0, rear = 0;
  queue[rear++] = createNode(initialState, NULL, '\0', 0);
  // Initialize a stack to store states
  Stack stack;
  initializeStack(&stack);
  while (front < rear)
  {
    PuzzleNode *currentNode = queue[front++];
    int blankRow, blankCol;
    findBlankPosition(currentNode->state, &blankRow,
&blankCol);
    // Check if the current state is the goal state
    if (isGoalState(currentNode->state, goalState))
    {
      // Push the solution path onto the stack
      while (currentNode != NULL)
      {
        push(&stack, currentNode);
        currentNode = currentNode->parent;
      }
      // Pop and print the states from the stack to reverse
the order
```

```
      while (stack.top != -1)
      {
        currentNode = pop(&stack);
        printState(currentNode->state);
      }
      return;
    }
    // Move the blank tile up
    if (blankRow > 0)
    {
      PuzzleNode *newNode = createNode(currentNode->state,
                                       currentNode, 'U',
currentNode->cost + 1);
      swap(newNode->state, blankRow, blankCol, blankRow - 1,
           blankCol);
      queue[rear++] = newNode;
    }
    // Move the blank tile down
    if (blankRow < N - 1)
    {
      PuzzleNode *newNode = createNode(currentNode->state,
                                       currentNode, 'D',
currentNode->cost + 1);
      swap(newNode->state, blankRow, blankCol, blankRow + 1,
           blankCol);
      queue[rear++] = newNode;
    }
    // Move the blank tile left
    if (blankCol > 0)
    {
      PuzzleNode *newNode = createNode(currentNode->state,
                                       currentNode, 'L',
currentNode->cost + 1);
      swap(newNode->state, blankRow, blankCol, blankRow,
           blankCol - 1);
      queue[rear++] = newNode;
    }
    // Move the blank tile right
    if (blankCol < N - 1)
    {
      PuzzleNode *newNode = createNode(currentNode->state,
currentNode, 'R', currentNode->cost + 1);
      swap(newNode->state, blankRow, blankCol, blankRow,
           blankCol + 1);
      queue[rear++] = newNode;
    }
  }
}
// Function to perform the Branch and Bound algorithm using
Least Cost strategy

void solveLC(int initialState[N][N], int goalState[N][N])
{
  // Priority queue to store the PuzzleNodes based on cost
  PuzzleNode *priorityQueue[10000];
  int front = 0, rear = 0;
  priorityQueue[rear++] = createNode(initialState, NULL, '\0',
0);

  // Initialize a stack to store states
  Stack stack;
  initializeStack(&stack);

  while (front < rear)
  {
    PuzzleNode *currentNode = priorityQueue[front++];
    int blankRow, blankCol;
    findBlankPosition(currentNode->state, &blankRow,
&blankCol);
    // Check if the current state is the goal state
    if (isGoalState(currentNode->state, goalState))
    {
      // Push the solution path onto the stack
      while (currentNode != NULL)
      {
        push(&stack, currentNode);
        currentNode = currentNode->parent;
      }

      // Pop and print the states from the stack to reverse
the order
      while (stack.top != -1)
      {
        currentNode = pop(&stack);
        printState(currentNode->state);
      }
      return;
    }
    // Move the blank tile up
    if (blankRow > 0)
    {
      PuzzleNode *newNode = createNode(currentNode->state,
currentNode, 'U', currentNode->cost + 1);
      swap(newNode->state, blankRow, blankCol, blankRow - 1,
           blankCol);
      priorityQueue[rear++] = newNode;
    }
    // Move the blank tile down
    if (blankRow < N - 1)
    {
      PuzzleNode *newNode = createNode(currentNode->state,
currentNode, 'D', currentNode->cost + 1);
      swap(newNode->state, blankRow, blankCol, blankRow + 1,
           blankCol);
      priorityQueue[rear++] = newNode;
    }
    // Move the blank tile left
    if (blankCol > 0)
    {
      PuzzleNode *newNode = createNode(currentNode->state,
```



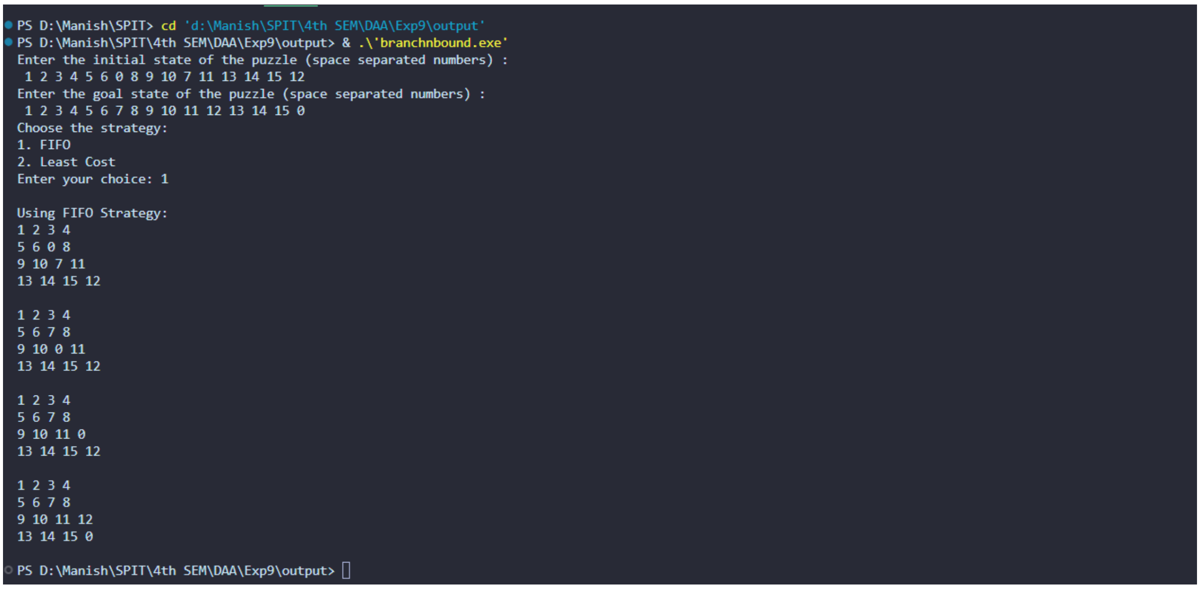
```
                                        currentNode, 'L',
currentNode->cost + 1);
      swap(newNode->state, blankRow, blankCol, blankRow,
           blankCol - 1);
      priorityQueue[rear++] = newNode;
    }
    // Move the blank tile right
    if (blankCol < N - 1)
    {
      PuzzleNode *newNode = createNode(currentNode->state,
currentNode, 'R', currentNode->cost + 1);
      swap(newNode->state, blankRow, blankCol, blankRow,
           blankCol + 1);
      priorityQueue[rear++] = newNode;
    }
  }
}
int main()
{
  int initialState[N][N], goalState[N][N];
  // Taking user input for the initial state
  printf("Enter the initial state of the puzzle (space
separated numbers) :\n ");
  for (int i = 0; i < N; i++)
  {
    for (int j = 0; j < N; j++)
    {
      scanf("%d", &initialState[i][j]);
    }
  }
  // Taking user input for the goal state
  printf("Enter the goal state of the puzzle (space separated
numbers) :\n ");
  for (int i = 0; i < N; i++)
  {
    for (int j = 0; j < N; j++)
    {
```



```
      scanf("%d", &goalState[i][j]);
    }
  }
  // Giving user option to choose between FIFO or LC strategy
 int choice;
printf("Choose the strategy:\n");
printf("1. FIFO\n");
printf("2. Least Cost\n");
printf("Enter your choice: ");
scanf("%d", &choice);
  switch (choice)
  {
  case 1:
    printf("\nUsing FIFO Strategy:\n");
    solveFIFO(initialState, goalState);
    break;
  case 2:
    printf("\nUsing Least Cost Strategy:\n");
    solveLC(initialState, goalState);
    break;
  default:
    printf("Invalid choice.\n");
    break;
  }
  return 0;
}
```

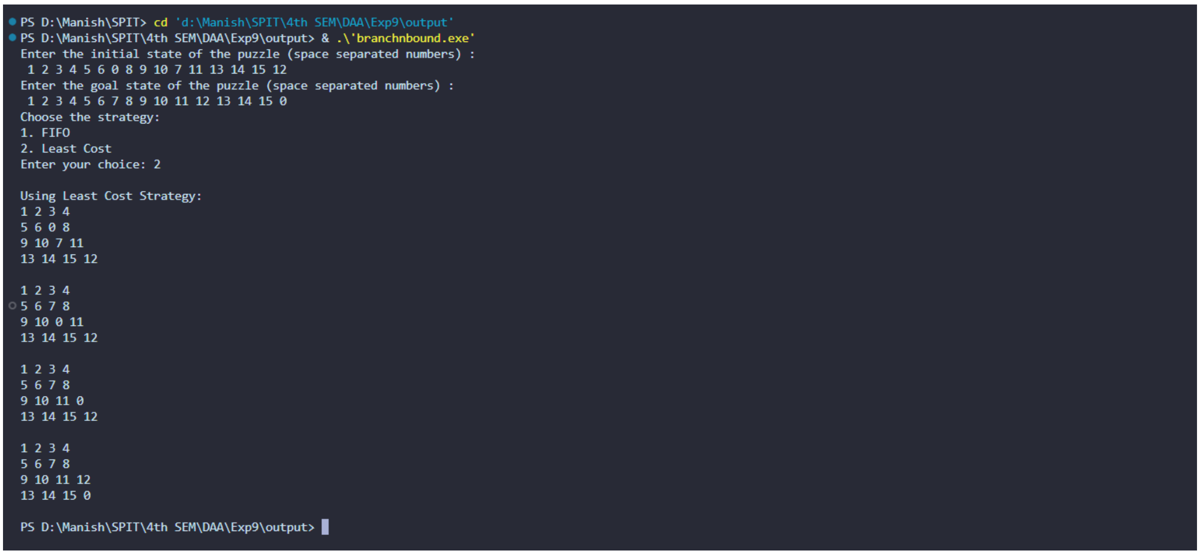
Output

1. FIFO



```
PS D:\Manish\SPIT> cd 'd:\Manish\SPIT\4th SEM\DAA\Exp9\output'
PS D:\Manish\SPIT\4th SEM\DAA\Exp9\output> & .\'branchnbound.exe'
Enter the initial state of the puzzle (space separated numbers) :
 1 2 3 4 5 6 0 8 9 10 7 11 13 14 15 12
Enter the goal state of the puzzle (space separated numbers) :
 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 0
Choose the strategy:
1. FIFO
2. Least Cost
Enter your choice: 1

Using FIFO Strategy:
1 2 3 4
5 6 0 8
9 10 7 11
13 14 15 12

1 2 3 4
5 6 7 8
9 10 0 11
13 14 15 12

1 2 3 4
5 6 7 8
9 10 11 0
13 14 15 12

1 2 3 4
5 6 7 8
9 10 11 12
13 14 15 0

PS D:\Manish\SPIT\4th SEM\DAA\Exp9\output> 
```

2. LC



```
PS D:\Manish\SPIT> cd 'd:\Manish\SPIT\4th SEM\DAA\Exp9\output'
PS D:\Manish\SPIT\4th SEM\DAA\Exp9\output> & .\'branchnbound.exe'
Enter the initial state of the puzzle (space separated numbers) :
 1 2 3 4 5 6 0 8 9 10 7 11 13 14 15 12
Enter the goal state of the puzzle (space separated numbers) :
 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 0
Choose the strategy:
1. FIFO
2. Least Cost
Enter your choice: 2

Using Least Cost Strategy:
1 2 3 4
5 6 0 8
9 10 7 11
13 14 15 12

1 2 3 4
5 6 7 8
9 10 0 11
13 14 15 12

1 2 3 4
5 6 7 8
9 10 11 0
13 14 15 12

1 2 3 4
5 6 7 8
9 10 11 12
13 14 15 0

PS D:\Manish\SPIT\4th SEM\DAA\Exp9\output> 
```

Conclusion

Hence, by completing this experiment I came to know about implementation of FIFO and LC using Branch and Bound.