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# Python3 program to solve
# Traveling Salesman Problem using
# Branch and Bound.
import math
maxsize = float('inf')

# Function to copy temporary solution
# to the final solution
def copyToFinal(curr_path):
    final_path[:N + 1] = curr_path[:]
    final_path[N] = curr_path[0]

# Function to find the minimum edge cost
# having an end at the vertex i
def firstMin(adj, i):
    min = maxsize
    for k in range(N):
        if adj[i][k] < min and i != k:
            min = adj[i][k]

    return min

# function to find the second minimum edge
# cost having an end at the vertex i
def secondMin(adj, i):
    first, second = maxsize, maxsize
    for j in range(N):
        if i == j:
            continue
        if adj[i][j] <= first:
            second = first
            first = adj[i][j]

        elif(adj[i][j] <= second and
             adj[i][j] != first):
            second = adj[i][j]

    return second

# function that takes as arguments:
# curr_bound -> lower bound of the root node
# curr_weight-> stores the weight of the path so far
# level-> current level while moving
# in the search space tree
# curr_path[] -> where the solution is being stored
# which would later be copied to final_path[]
def TSPRec(adj, curr_bound, curr_weight,
           level, curr_path, visited):
    global final_res

    # base case is when we have reached level N
    # which means we have covered all the nodes once
    if level == N:

        # check if there is an edge from
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    # last vertex in path back to the first vertex
    if adj[curr_path[level - 1]][curr_path[0]] != 0:

        # curr_res has the total weight
        # of the solution we got
        curr_res = curr_weight + adj[curr_path[level - 1]]\
                                 [curr_path[0]]
        if curr_res < final_res:
            copyToFinal(curr_path)
            final_res = curr_res
    return

# for any other level iterate for all vertices
# to build the search space tree recursively
for i in range(N):

    # Consider next vertex if it is not same
    # (diagonal entry in adjacency matrix and
    #  not visited already)
    if (adj[curr_path[level-1]][i] != 0 and
                        visited[i] == False):
        temp = curr_bound
        curr_weight += adj[curr_path[level - 1]][i]

        # different computation of curr_bound
        # for level 2 from the other levels
        if level == 1:
            curr_bound -= ((firstMin(adj, curr_path[level - 1]) +
                           firstMin(adj, i)) / 2)
        else:
            curr_bound -= ((secondMin(adj, curr_path[level - 1]) +
                            firstMin(adj, i)) / 2)

        # curr_bound + curr_weight is the actual lower bound
        # for the node that we have arrived on.
        # If current lower bound < final_res,
        # we need to explore the node further
        if curr_bound + curr_weight < final_res:
            curr_path[level] = i
            visited[i] = True

            # call TSPRec for the next level
            TSPRec(adj, curr_bound, curr_weight,
                   level + 1, curr_path, visited)

        # Else we have to prune the node by resetting
        # all changes to curr_weight and curr_bound
        curr_weight -= adj[curr_path[level - 1]][i]
        curr_bound = temp

        # Also reset the visited array
        visited = [False] * len(visited)
        for j in range(level):
            if curr_path[j] != -1:
                visited[curr_path[j]] = True
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# This function sets up final_path
def TSP(adj):

    # Calculate initial lower bound for the root node
    # using the formula 1/2 * (sum of first min +
    # second min) for all edges. Also initialize the
    # curr_path and visited array
    curr_bound = 0
    curr_path = [-1] * (N + 1)
    visited = [False] * N

    # Compute initial bound
    for i in range(N):
        curr_bound += (firstMin(adj, i) +
                       secondMin(adj, i))

    # Rounding off the lower bound to an integer
    curr_bound = math.ceil(curr_bound / 2)

    # We start at vertex 1 so the first vertex
    # in curr_path[] is 0
    visited[0] = True
    curr_path[0] = 0

    # Call to TSPRec for curr_weight
    # equal to 0 and level 1
    TSPRec(adj, curr_bound, 0, 1, curr_path, visited)

# Driver code

# Adjacency matrix for the given graph
adj = [[0, 10, 15, 20],
       [10, 0, 35, 25],
       [15, 35, 0, 30],
       [20, 25, 30, 0]]
N = 4

# final_path[] stores the final solution
# i.e. the // path of the salesman.
final_path = [None] * (N + 1)

# visited[] keeps track of the already
# visited nodes in a particular path
visited = [False] * N

# Stores the final minimum weight
# of shortest tour.
final_res = maxsize

TSP(adj)

print("Minimum cost :", final_res)
print("Path Taken : ", end = ' ')
for i in range(N + 1):
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    print(final_path[i], end = ' ')

# This code is contributed by ng24_7
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