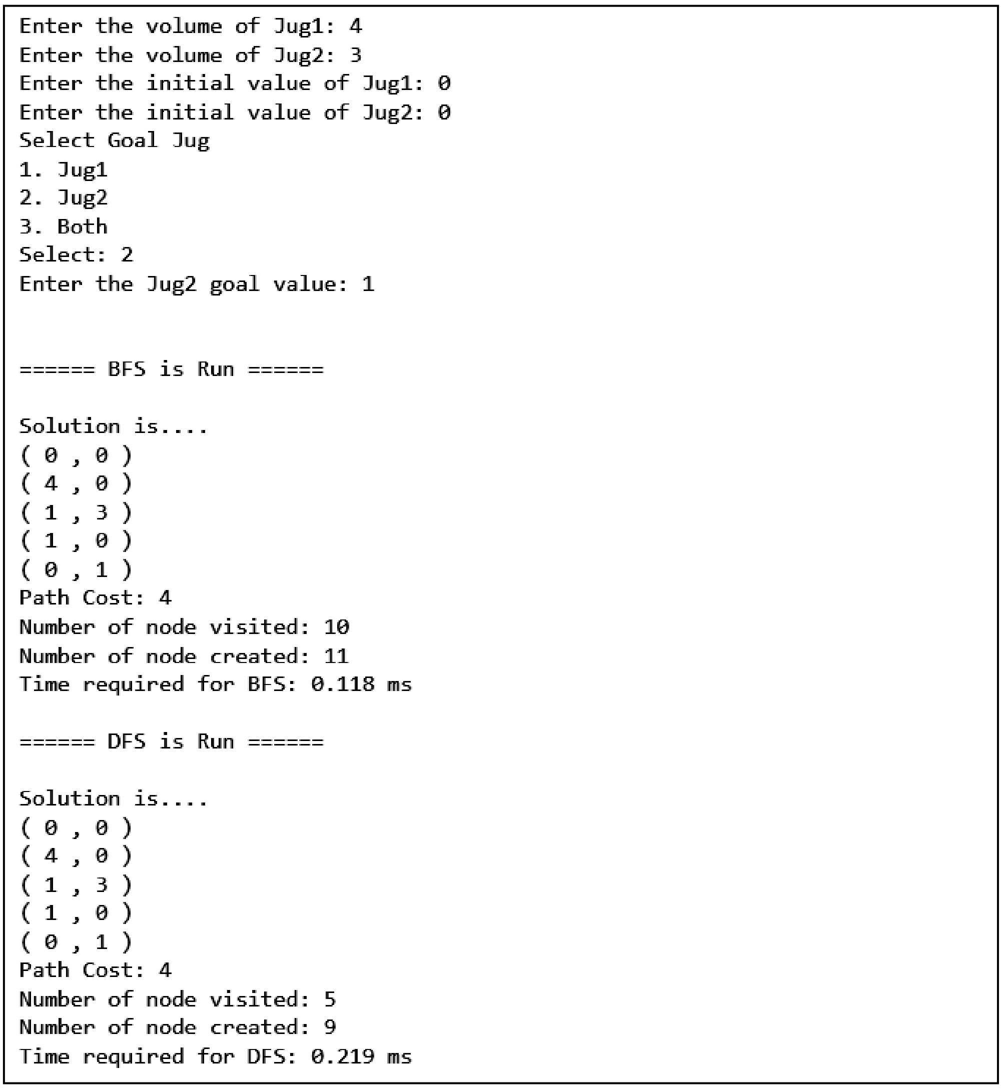
**Aim: Write a program to implement a Water Jug Problem using Python and to solve a Water Jug Problem by using BFS (without using any libraries or packages of python).**

- **Program should be written in generalized way to solve by using any capacity of jug.**
- **Find the minimum number of steps to reach any the below-mentioned goal states.**
- **Find execution time of BFS algorithm. (Only “time” and “random” packages can be used in python if it is necessary to use)**

**Program:**

```
import time
import random

class node:
  def __init__(self,parentNode):
    self.jug1=0
    self.jug2=0
    self.parentNode=parentNode

def operation(i,inputNode,visitedNodeList):
  x=inputNode.jug1
  y=inputNode.jug2
  result=x+y

  if(i==1 and x<jug1):
    x=jug1

  elif(i==2 and y<jug2):
    y=jug2

  elif(i==3 and x>0):
    x=0

  elif(i==4 and y>0):
    y=0

  elif(i==5 and 0 < result >= jug1 and y>0):
    y=(y-(jug1-x))
    x=jug1

  elif(i==6 and 0 < result >= jug2 and x>0):
    x=(x-(jug2-y))
    y=jug2

  elif(i==7 and 0 < result <= jug1 and y >= 0):
    x=result
    y=0

  elif(i==8 and 0 < result <= jug2 and x >= 0):
    y=result
    x=0

  if(x==inputNode.jug1 and y==inputNode.jug2):
    return None

  if([x,y] not in visitedNodeList):
    newNode = node(inputNode)
    newNode.jug1=x
    newNode.jug2=y
    return newNode
  return None

def generateNode(nodeData, method, visitedNodeList):
  nodeList=[]
  rng = range(1,9)
  if(method.upper()=="DFS"):
    rng = random.sample(range(1,9), 8)
  for i in rng:
    genNode = operation(i,nodeData,visitedNodeList)
    if(genNode!=None):
      nodeList.append(genNode)
  return nodeList


class blindSearch:
  def __init__(self):
    self.nodeList=[]

  def find(self,initNode,destinationNode,method):
    self.nodeList.append(initNode)
    visitedNodeList=[]
    if(method.upper()=="DFS"):
      while len(self.nodeList)!=0:
        tempNode = self.nodeList.pop()
        visitedNodeList.append([tempNode.jug1,tempNode.jug2])
        if(tempNode.jug1 == destinationNode.jug1 and tempNode.jug2 == destinationNode.jug2):
          return [tempNode,len(visitedNodeList),len(visitedNodeList)+len(self.nodeList)]
        else:
          self.nodeList.extend(generateNode(tempNode, "DFS",visitedNodeList))
    elif(method.upper()=="BFS"):
      while len(self.nodeList)!=0:
        tempNode = self.nodeList.pop(0)
        visitedNodeList.append([tempNode.jug1,tempNode.jug2])
        if(tempNode.jug1 == destinationNode.jug1 and tempNode.jug2 == destinationNode.jug2):
          return [tempNode,len(visitedNodeList),len(visitedNodeList)+len(self.nodeList)]
        else:
          self.nodeList.extend(generateNode(tempNode, "BFS",visitedNodeList))
    else:
      print("The search method name is incorrect.")
    return [None,len(visitedNodeList),len(visitedNodeList)+len(self.nodeList)]

def printPath(getNode):
  nodeList=[getNode]
  tempNode = getNode.parentNode
  while tempNode!=None:
    nodeList.append(tempNode)
    tempNode=tempNode.parentNode
  return [reversed(nodeList),len(nodeList)-1]

posibleNode=False
try:
  jug1 = int(input("\n\nEnter the volume of Jug1: "))

  if(not jug1>=0):
    raise Exception("Sorry, no numbers below zero")

  jug2 = int(input("Enter the volume of Jug2: "))

  if(not jug2 >= 0):
    raise Exception("Sorry, no numbers below zero")

  initJug1 = int(input("Enter the initial value of Jug1: "))
  if(not initJug1>=0):
    raise Exception("Sorry, no numbers below zero")
  else:
    if(not initJug1<=jug1):
      raise Exception("Invalid initial value of Jug1")

  initJug2 = int(input("Enter the initial value of Jug2: "))

  if(not initJug2 >= 0):
    raise Exception("Sorry, no numbers below zero")
  else:
    if(not initJug2 <= jug2):
      raise Exception("Invalid initial value of Jug2")

  initNode = node(None)
  initNode.jug1 = initJug1
  initNode.jug2 = initJug2

  destinationNode = node(None)
  print("Select Goal Jug")
  print("1. Jug1")
  print("2. Jug2")
  print("3. Both")
  selectJug=int(input("Select: "))
  if(selectJug==1):
    goalJug1 = int(input("Enter the Jug1 goal value: "))
    if(goalJug1<=jug1):
      posibleNode=True
      destinationNode.jug1=goalJug1
    else:
      raise Exception("Goal Jug1 value not possible. It must be less than or equle to volume")
  elif(selectJug==2):
    goalJug2 = int(input("Enter the Jug2 goal value: "))
    if(goalJug2<=jug2):
      posibleNode=True
      destinationNode.jug2=goalJug2
    else:
      raise Exception("Goal Jug2 value not possible. It must be less than or equle to volume")
  elif(selectJug==3):
    goalJug1 = int(input("Enter the Jug1 goal value: "))
    if(goalJug1<=jug1):
      posibleNode=True
      destinationNode.jug1=goalJug1
    else:
      raise Exception("Goal Jug1 value not possible. It must be less than or equle to volume")
    goalJug2 = int(input("Enter the Jug2 goal value: "))
    if(goalJug2<=jug2):
      posibleNode=True
      destinationNode.jug2=goalJug2
    else:
      raise Exception("Goal Jug2 value not possible. It must be less than or equle to volume")
  else:
    raise Exception("Error: Invalid selection; please try again!")

  if(posibleNode):
    print("\n\n====== BFS is Run ======\n")
    initTime = time.time()
    result = blindSearch().find(initNode,destinationNode,"BFS")
    finishTime = time.time()

    if(result[0]!=None):
      print("Solution is....")
      pathList = printPath(result[0])
      for i in pathList[0]:
        print(str.format("( {0} , {1} )",i.jug1,i.jug2))
      print(str.format("Path Cost: {0}",pathList[1]))
    else:
      print("The solution is not possible!")
    print(str.format("Number of node visited: {0}",result[1]))
    print(str.format("Number of node created: {0}",result[2]))
    print(str.format("Time required for BFS: {:.3f} ms\n",(finishTime-initTime)*1000))


    print("====== DFS is Run ======\n")
    initTime = time.time()
    result = blindSearch().find(initNode,destinationNode,"DFS")
    finishTime = time.time()
    if(result[0]!=None):
      print("Solution is....")
      pathList = printPath(result[0])
      for i in pathList[0]:
        print(str.format("( {0} , {1} )",i.jug1,i.jug2))
      print(str.format("Path Cost: {0}",pathList[1]))
    else:
      print("The solution is not possible!")
    print(str.format("Number of node visited: {0}",result[1]))
    print(str.format("Number of node created: {0}",result[2]))
    print(str.format("Time required for DFS: {:.3f} ms\n\n",(finishTime-initTime)*1000))

except ValueError:
  print("Invalid Value: Only an integer value is allowed.")
except Exception as ex:
  print(ex)
```

**Output:**



```
Enter the volume of Jug1: 4
Enter the volume of Jug2: 3
Enter the initial value of Jug1: 0
Enter the initial value of Jug2: 0
Select Goal Jug
1. Jug1
2. Jug2
3. Both
Select: 2
Enter the Jug2 goal value: 1


====== BFS is Run ======

Solution is....
( 0 , 0 )
( 4 , 0 )
( 1 , 3 )
( 1 , 0 )
( 0 , 1 )
Path Cost: 4
Number of node visited: 10
Number of node created: 11
Time required for BFS: 0.118 ms

====== DFS is Run ======

Solution is....
( 0 , 0 )
( 4 , 0 )
( 1 , 3 )
( 1 , 0 )
( 0 , 1 )
Path Cost: 4
Number of node visited: 5
Number of node created: 9
Time required for DFS: 0.219 ms
```