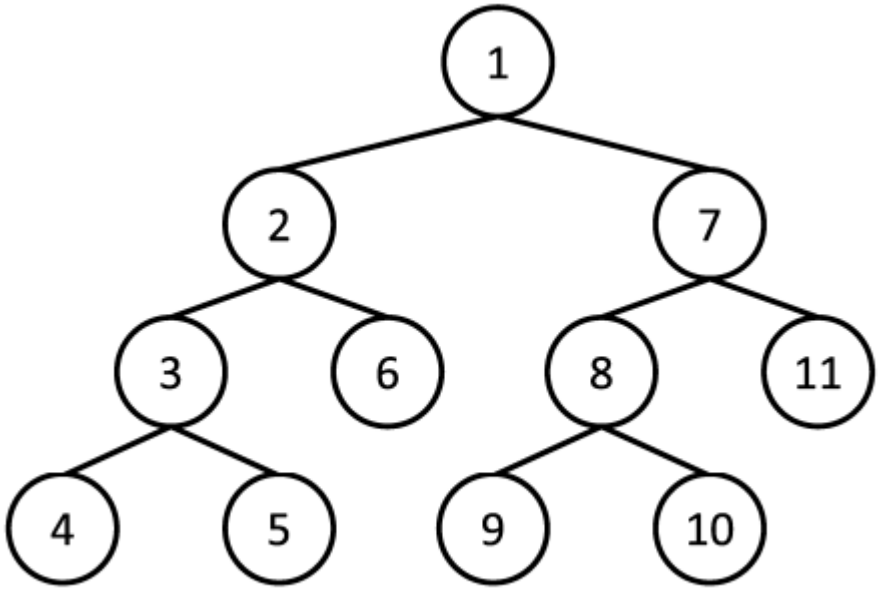
目录

- 深度优先搜索和栈
- 广度优先搜索和队列
- Uniform Cost Search和优先队列
- A star

深度优先搜索

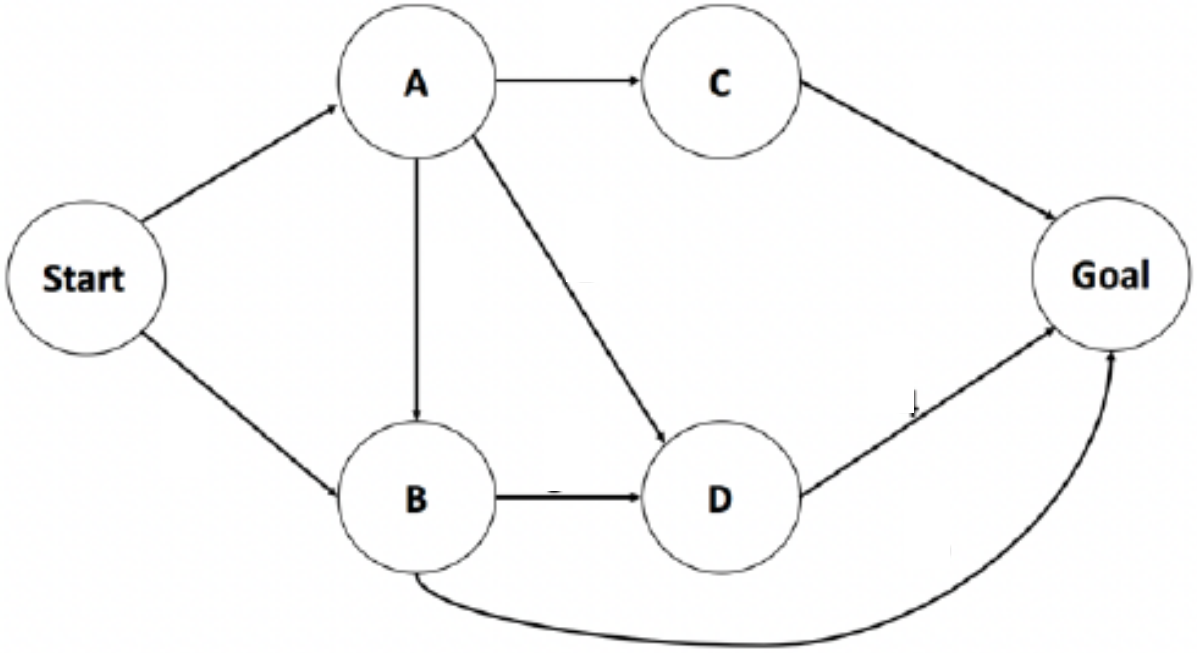
- 深度优先搜索算法从某个状态开始，不断地转移状态直到无法转移，然后退回前一步的状态，继续转移到其他状态，如此不断重复。



状态转移的顺序

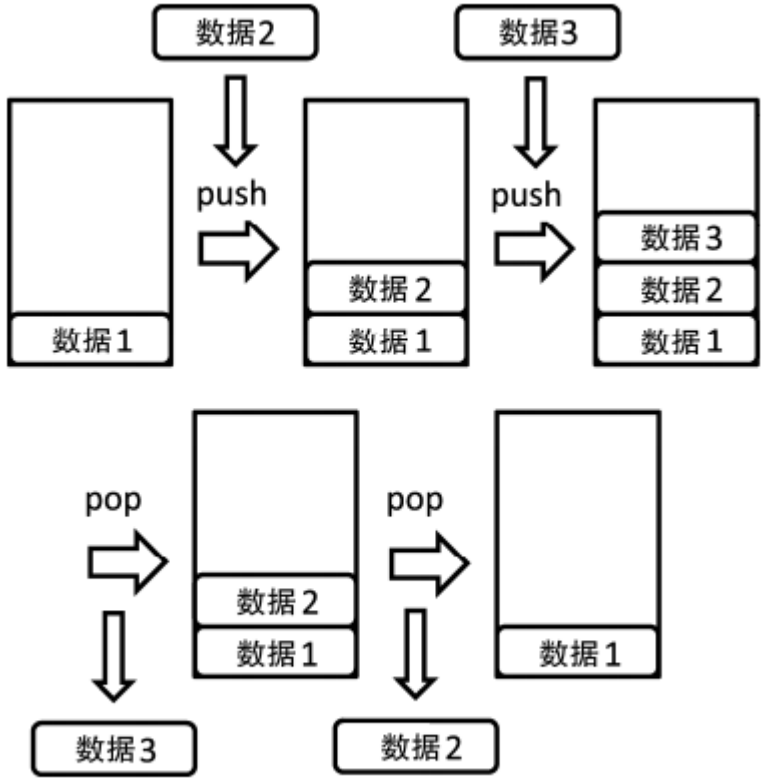
```
function  Depth-FIRST-SEARCH(problem) returns a solution, or failure

  node ← a node with STATE = problem.INITIAL-STATE, PATH-COST = 0
  if problem.GOAL-TEST(node.STATE) then return SOLUTION(node)
  frontier ← a LIFO stack with node as the only element
  explored ← an empty set
  loop do
    if EMPTY?(frontier) then return failure
    node ← POP(frontier)  /* choose the deepest node in frontier*/
    add node.STATE to explored
    for each action in problem.ACTIONS(node.STATE) do
      child ← CHILD-NODE(problem, node, action)
      if child.STATE is not in explored or frontier then
        if problem.GOAL-TEST(child.STATE) then return SOLUTION(child)
        frontier ← INSERT(child, frontier)
```


A
C
Start
Goal
B
D

LIFO-栈

- 栈（stack）又名堆栈，它是一种运算受限的线性表。
- 其限制是仅允许在表的一端进行插入和删除运算。这一端被称为栈顶，相对地，把另一端称为栈底。
- 向一 个栈插入新元素又称作进栈、入栈或压栈，它是把新元素放到栈顶元素的上面，使之成为新的栈顶元素。
- 从一个栈删除元素又称作出栈或退栈，它是把栈顶元素删除 掉，使其相邻的元素成为新的栈顶元素。



栈的操作

伪代码

STACK-EMPTY(S)

- if S.top == 0：
  - return True
- else return False

PUSH(S, x)

- S.top = S.top + 1
- S[S.top] = x

POP(S)

- if STACK-EMPTY(S)
  - error ‘underflow’
- else:
  - S.top = S.top – 1
  - return S[S.top+1]

```python
class Stack(object):
    def __init__(self):
        self._elements = []
        self._size = 0

    def stack_empty(self):
        if self._size <= 0:
            return True
        else:
            return False

    def insert(self, e):
        self._elements = self._elements + [e]
        # self._elements.append(e)
        self._size += 1

    def pop(self):
        if self.stack_empty():
            raise Exception('Stack underflow!')
        e = self._elements[-1]
        self._size -= 1
        self._elements = self._elements[:self._size]
        # del self._elements[-1]
        return e

    def get_size(self):
        return self._size
```

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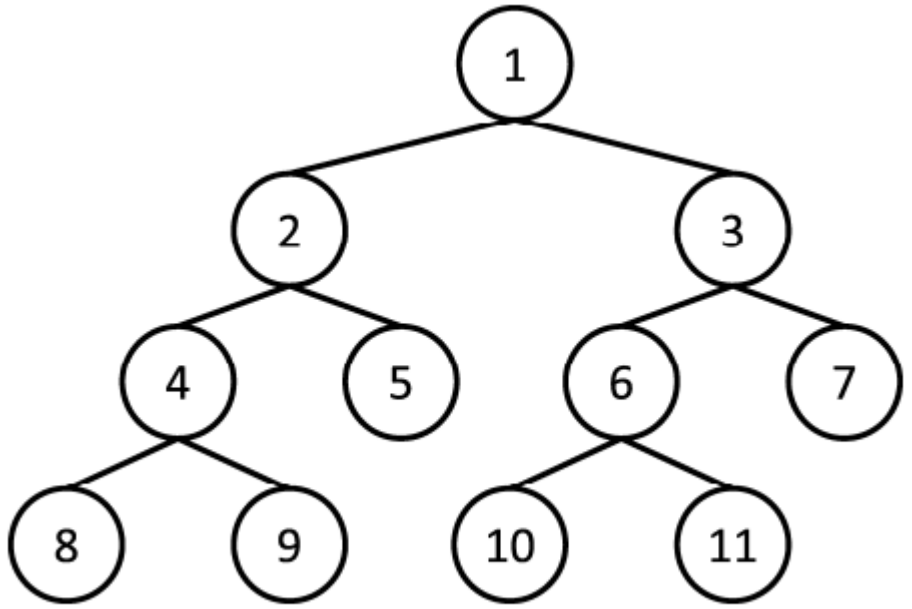
广度优先搜索BFS

- BFS总是先搜索距离初始状态近的状态。
- 也就是说，开始状态→1次转移可以到达的所有状态→2次转移可以到达的所有状态→……

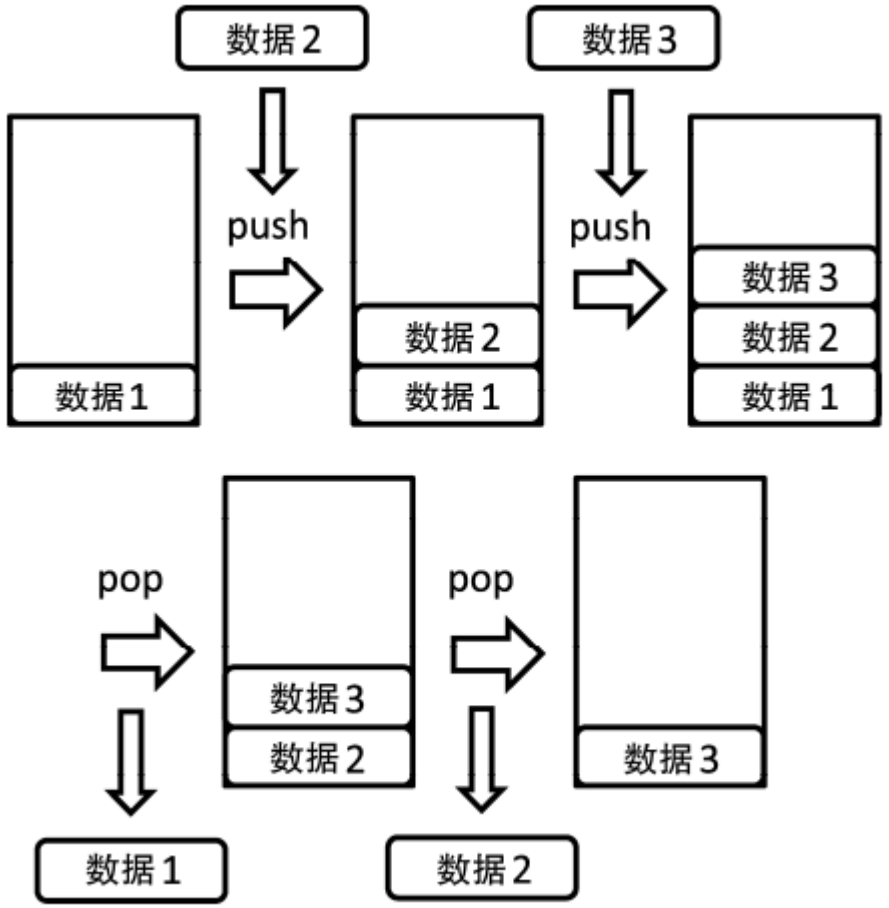


状态转移的顺序

```
function BREADTH-FIRST-SEARCH(problem) returns a solution, or failure
    node ← a node with STATE = problem.INITIAL-STATE, PATH-COST = 0
    if problem.GOAL-TEST(node.STATE) then return SOLUTION(node)
    frontier ← a FIFO queue with node as the only element
    explored ← an empty set
    loop do
        if EMPTY?(frontier) then return failure
        node ← POP(frontier)   /* chooses the shallowest node in frontier */
        add node.STATE to explored
        for each action in problem.ACTIONS(node.STATE) do
            child ← CHILD-NODE(problem, node, action)
            if child.STATE is not in explored or frontier then
                if problem.GOAL-TEST(child.STATE) then return SOLUTION(child)
                frontier ← INSERT(child, frontier)
```

FIFO-队列

- 队列也是一种特殊的线性表
- 特殊之处在于它只允许在表的前端（front）进行删除操作，而在表的后端（rear）进行插入操作，和栈一样，队列是一种操作受限制的线性表。
- 进行插入操作的端称为队尾，进行删除操作的端称为队头。



队列的操作

伪代码

STACK-EMPTY(S)

- if S.size == 0：
  - return True
- else return False

INSERT(S, x)

- S.size = S.size + 1
- S[S.size] = x

POP(S)

- if STACK-EMPTY(S)
  - error ‘underflow’
- else:
  - e = S[0]
  - S = S[1:S.size]
  - S.size = S.size – 1
  - return e

```python
class Queue(object):
    def __init__(self):
        self._elements = []
        self._size = 0

    def queue_empty(self):
        if self._size <= 0:
            return True
        else:
            return False

    def insert(self, e):
        self._elements = self._elements + [e]
        # self._elements.append(e)
        self._size += 1

    def pop(self):
        if self.queue_empty():
            raise Exception('Queue underflow!')
        e = self._elements[0]
        self._elements = self._elements[1:]
        self._size -= 1
        return e

    def get_size(self):
        return self._size
```

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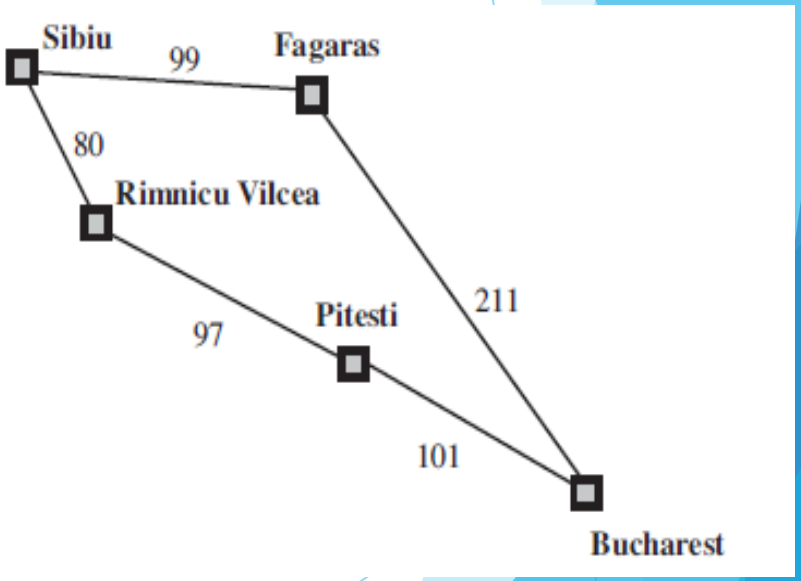
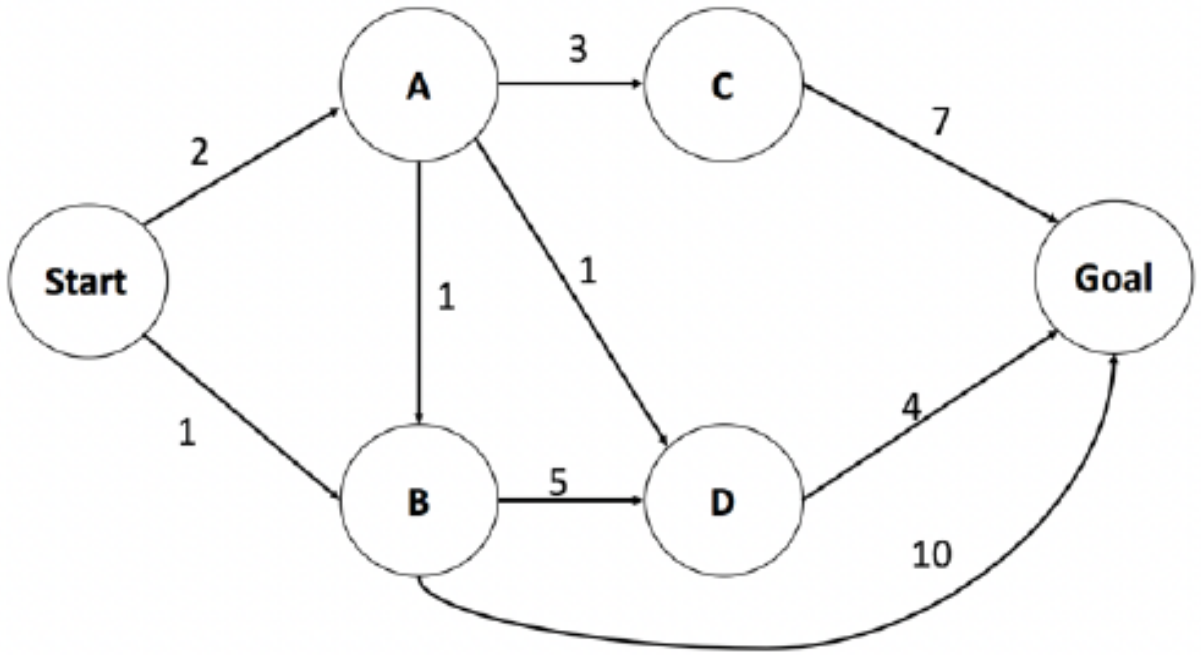
Uniform Cost Search

- Uniform Cost Search 和 BFS 一样是先搜索距离初始节点较近的节点，但是二者对于距离的定义方式不同，一般来说Uniform Cost Search当中每一条边的权重是不太一样的。如果Uniform Cost Search的每一条边上定义的距离都是1，那么Uniform Cost Search 等价于BFS。



```
function UNIFORM-COST-SEARCH(problem) returns a solution, or failure

  node ← a node with STATE = problem.INITIAL-STATE, PATH-COST = 0
  frontier ← a priority queue ordered by PATH-COST, with node as the only element
  explored ← an empty set
  loop do
    if EMPTY?(frontier) then return failure
    node ← POP(frontier)  /* chooses the lowest-cost node in frontier */
    if problem.GOAL-TEST(node.STATE) then return SOLUTION(node)
    add node.STATE to explored
    for each action in problem.ACTIONS(node.STATE) do
      child ← CHILD-NODE(problem, node, action)
      if child.STATE is not in explored or frontier then
        frontier ← INSERT(child, frontier)
      else if child.STATE is in frontier with higher PATH-COST then
        replace that frontier node with child
```


A
C
Start
Goal
B
D
2
3
7
1
1
1
4
5
10

Priority Queue-优先队列？

- 入队之后的排序不再由入队的时间顺序决定，转而由数据的值的顺序来决定。
- 进行取出操作的时候，拿出在在优先队列中排名最好的那一个数据。

用二叉堆实现优先队列

- 优先队列的插入更多使用的是堆排序算法。
- 可以直接调用heapq
- 更多的内容可以参考算法导论第六章堆排序

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A star

- A star 在Uniform Cost Search的基础上利用 $h(n)$ 估计从当前节点 n 到最终节点需要走的实际距离 $f(n)$，当 $h(n)$ 估计满足下面的条件的时候，A star可以保证选出来的路径是最优的。

$$f(n) \geq h(n)$$

$$h(n) \leq c(n, a, n') + h(n')$$

$c(n, a, n')$为从n到n'所走的实际距离

假设$f(n)$是初始节点到n的最优路径的值，我们将 $f(n) + h(n)$ 作为节点 n 的值放入优先队列进行排序。

- Lab：Python3
- Project：Python2
- Pycharm(建议)
- 浏览器输入 10.88.3.60/JudgeOnline
  学号作为User ID申请账号

Online Judgement

问题：求和
输入 1+1（i+j, i,j 在0~9之间）
输出 2

```
def  easy_sum(s):
        raise exception('完成str转int，并进行加操作')

def main():
        s = input().strip()
        print(easy(s))

If __name__=='__main__':
        main()
```

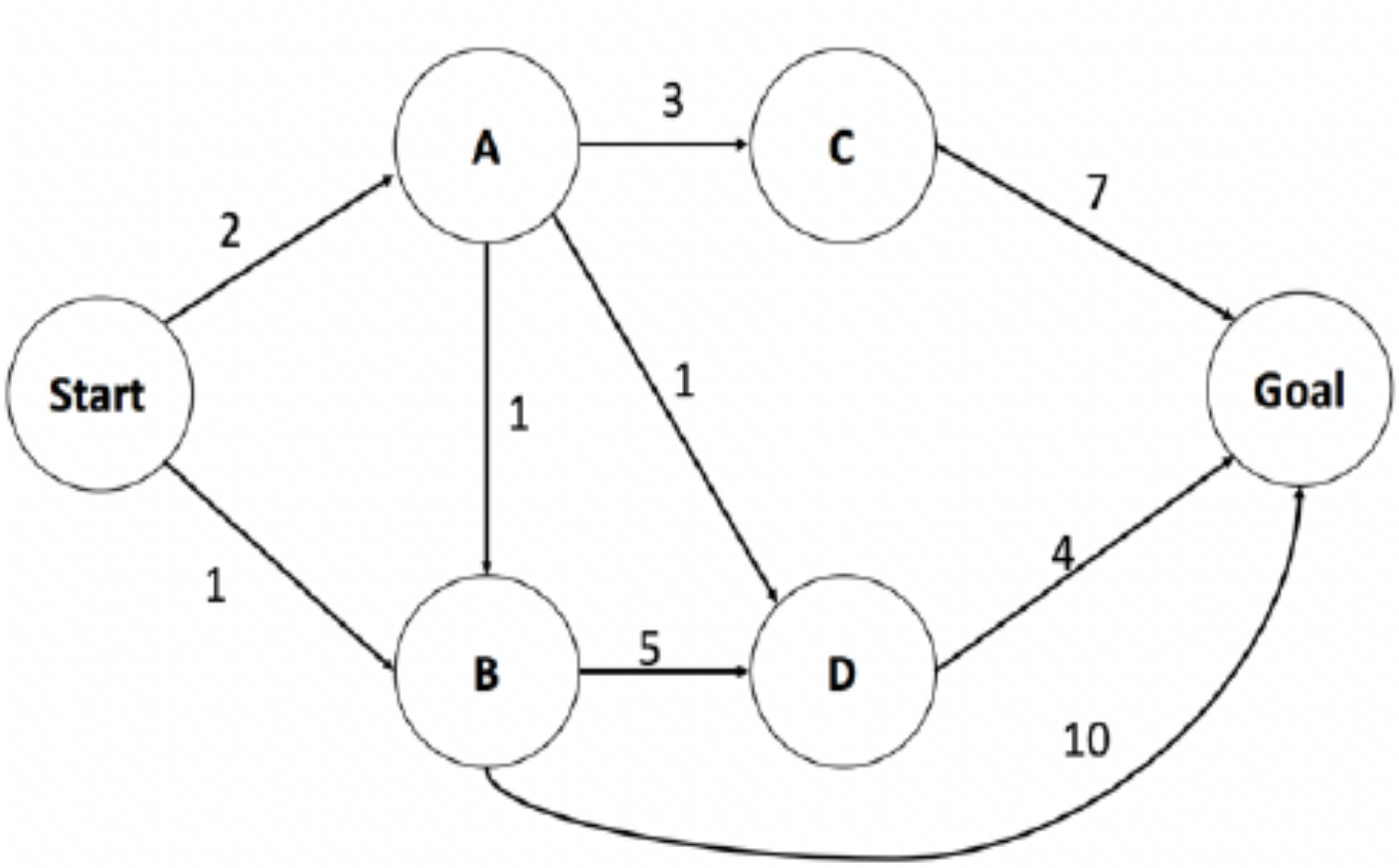
```
def  easy_sum(s):
        a1, a2 = int(s[0]), int(s[-1])
      return a1 + a2

def main():
      s = input().strip()
      print(easy(s))

If __name__==‘__main__’:
      main()
```

Lab-1

- 任务：
  1. 实现 Uniform Cost Search 算法
  2. 找到并输出从’Start’节点到’Goal’节点的最优搜索路径
  3. 若无可行路径，输出’ Unreachable’
  4. Time Limits 2000ms
  5. 先在自己的电脑上跑通，不要直接在OJ上写！

- 注意：
  1. 在OJ上提交并通过测试
  2. OJ成绩计入平时分，通过即满分

Lab-1



Lab-1

- Sample Input

  Start A 2
  Start B 1
  A B 1
  A C 3
  A D 1
  B D 5
  B Goal 10
  C Goal 7
  D Goal 4
  END

- Sample Output

  Start->A->D->Goal

Input

Each line presents an edge consisting of a tuple of start node, end node and cost. Input ends with 'END'.

Output

One line for the optimal path in visit order, join by '->'. If there is no solution, print ‘Unreachable’.

Online Judgement

```
def main():
        actions = []
        while True:
            a = input().strip()
            if a != 'END':
                a = a.split()
                actions += [a]
            else:
                break
        graph_problem = problem('Start', actions)
        answer = UCS(graph_problem)
        s = "->"
        if answer == 'Unreachable':
            print(answer)
        else:
            path = s.join(answer)
            print(path)

if __name__=='__main__':
    main()
```

处理之后：

a = [‘start node’,

‘end node’,

‘distance’]

例如：

Start A 2

[‘Start’, ‘A’, ‘2’]

```python
import heapq
class PriorityQueue(object):
    def __init__(self):
        self.heap = []
        self.count = 0

    def push(self, item, priority):
        entry = (priority, self.count, item)
        heapq.heappush(self.heap, entry)
        self.count += 1

    def pop(self):
        (_, _, item) = heapq.heappop(self.heap)
        return item

    def isEmpty(self):
        return len(self.heap) == 0

    def update(self, item, priority):
        for index, (p, c, i) in enumerate(self.heap):
            if i == item:
                if p <= priority:
                    break
                del self.heap[index]
                self.heap.append((priority, c, item))
                heapq.heapify(self.heap)
                break
        else:
            self.push(item, priority)

class node:
    """define node"""
    def __init__(self, state, parent, path_cost, action):
        self.state = state
        self.parent = parent
        self.path_cost = path_cost
        self.action = action
```

```python
class problem:
    """searching problem"""
    def __init__(self, initial_state, actions):
        self.initial_state = initial_state
        self.actions = actions
        # 可以在这里随意添加代码或者不加

    def search_actions(self, state):
        raise Exception('获取state的所有克星的动作')

    def solution(self, node):
        raise Exception('获取从初始节点到node的路径')

    def transition(self, state, action):
        raise Exception('节点的状态（名字）经过action转移之后的状态（名字）')

    def goal_test(self, state):
        raise Exception('判断state是不是终止节点')

    def step_cost(self, state1, action, state2):
        raise Exception('获得从state1到通过action到达state2的cost')

    def child_node(self, node_begin, action):
        raise Exception('获取从起始节点node_begin经过action到达的node')

def UCS(problem):
    node_test = node(problem.initial_state, '', 0, '')
    frontier = PriorityQueue()
    frontier.push(node_test, node_test.path_cost)
    explored = []
    raise Exception('进行循环')
```