

APLIKASI ENKRIPSI DAN DEKRIPSI PESAN DENGAN ALGORITMA HUFFMAN MENGGUNAKAN PYTHON 2.7

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ABSTRAK

Tujuan penulisan ini adalah untuk menjelaskan pembuatan aplikasi sederhana pengenalan kriptografi dengan menggunakan algoritma Huffman. Pertukaran informasi dapat mudah dilakukan dengan adanya media penyimpanan yang dapat dipindahkan antar komputer atau menggunakan surat elektronik. Terkadang ada informasi yang bersifat pribadi dan rahasia dan hanya orang tertentu yang boleh membaca informasi tersebut. Untuk itu dalam tulisan ini dibahas tentang perancangan program aplikasi yang bertujuan untuk mengenkripsi dan mendekripsi pesan menggunakan algoritma Huffman. Hasil akhir dari tulisan ini adalah suatu program aplikasi yang menghasilkan pesan acak yang sulit diterjemahkan jika tidak mengetahui cara untuk membukanya dan terbatas pada karakter alphabet (ASCII)

Kata-kunci : kriptografi, enkripsi, dekripsi, Huffman.

PENDAHULUAN

Kriptografi

Kriptografi merupakan seni dan ilmu menyembunyikan informasi dari penerima yang tidak berhak. Kata cryptography berasal dari kata Yunani kryptos (tersembunyi) dan graphein (menulis).

Kriptografi mempunyai tujuan antara lain :

- a. Kerahasiaan Data (Confidentiality). Untuk melindungi identitas pemakai atau isi pesan agar tidak dapat dibaca oleh orang lain yang tidak berhak.
- b. Integritas Data (Data Integrity). Untuk melindungi pesan agar tidak diubah oleh orang lain.
- c. Autentikasi (Authentication). Untuk menjamin keaslian pesan.
- d. Pemampatan File yaitu ukuran file menjadi lebih kecil dari file aslinya

Proses yang digunakan untuk menyamarkan atau menyembunyikan plaintext tersebut disebut dengan enkripsi. Teks yang sudah disamarkan atau disembunyikan pada proses enkripsi berisi informasi yang tidak dapat atau tidak mudah dibaca dan dimengerti dengan jelas. Teks hasil enkripsi ini disebut dengan ciphertext.

Proses kebalikan enkripsi, yaitu mengubah ciphertext menjadi plaintext disebut dengan proses dekripsi. Diperlukan kunci yaitu kode untuk melakukan enkripsi dan dekripsi.

Algoritma Huffman adalah salah satu teknik dalam kompresi data dari karakterASCII yang menggunakan struktur data binary tree. Tujuan utama Algoritma Huffman adalah bagaimana memampatkan / mengecilkan ukuran file tanpa mengubah isinya. Artinya ketika file yang diterima akan digunakan , isinya dapat dikembalikan kepada bentuk aslinya. Dalam penulisan ini Algoritma Huffman digunakan untuk mengenkripsi / menyembunyikan isi file asli sehingga tidak dapat dibaca bagi penerima yang tidak berhak.

METODE PENELITIAN

Algoritma Huffman:

1. Menghitung frekuensi masing-masing karakter (karakter, frekuensi)
2. Frekuensi tersebut diurutkan dari terendah ke tertinggi (Menaik)
3. Buat node baru yang berisi gabungan dari node dengan frekuensi terkecil yang terletak di sebelah kiri kemudian diurutkan kembali frekuensi dari terendah ke tertinggi (frekuensi karakter sebelah kiri selalu yang terendah)
4. Ulangi langkah 1, 2, dan 3 hingga hanya ada satu node (node akar)

Contoh data yang akan dikirim ABCACAD

Karakter	Frekuensi	Kode ASCII
A	3	01000001
B	1	01000010
C	2	01000011
D	1	01000100

Maka ABCACAD akan di ubah menjadi rangkaian bit string sebanyak 56 bit yaitu

01000001 01000010 01000011 01000001 01000011 01000001 01000100

A B C A C A D

Dimana jika string tersebut diencoding dengan algoritma huffman, akan memakan memori yang lebih kecil dari itu. Karena jumlah bit yang merepresentasikan suatu character dalam algoritma huffman bersifat dinamis, sehingga satu character dengan lainnya akan berbeda dalam jumlah bitnya.

Algoritma Huffman diaplikasikan pada ABCACAD adalah sebagai berikut

1. Menghitung frekuensi masing-masing karakter A, B, C, dan D yang akan di kirim

A = 3, B = 1, C = 2, dan D = 1

2. Frekuensi tersebut di urutkan makin naik sebagai berikut

B D C A

1 1 2 3

3. Pohon Huffman dibuat dengan mengikuti langkah-langkah sebagai berikut

- 3.1 Buat 4 node untuk masing-masing pasangan yaitu Karakter, Frekuensi

B, 1

D, 1

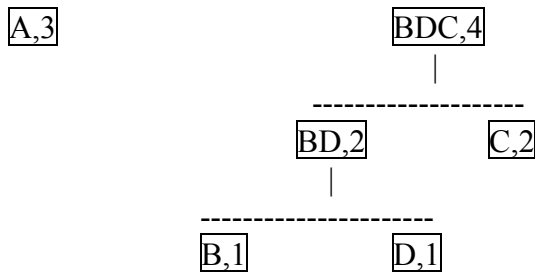
C, 2

A, 3

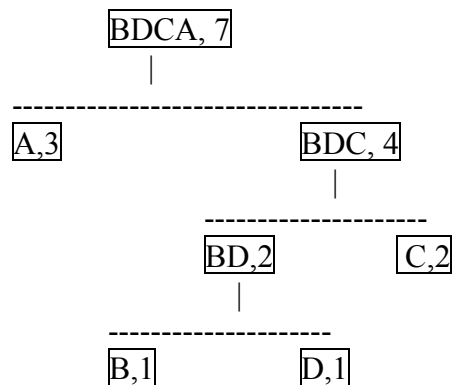
3.2. Pilihlah dua node dengan frekuensi terkecil(node paling kiri / merupakan tempat dengan frekuensi paling rendah) dan buatlah node baru yang isinya merupakan gabungan dua node terkecil tersebut isinya merupakan gabungan dua node terkecil tersebut. Node baru tersebut menjadi bapak dari dua node terkecil tersebut. Node(BD,2) menjadi bapak dari node(B,1) dan node(D,1) serta diurutkan bersama sama node yang lain. (node(C,2) dan node(A,3).



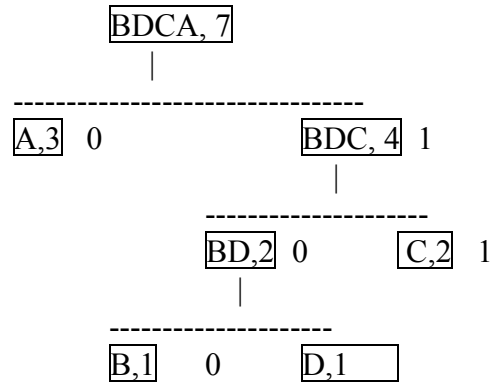
3.3 Ulangi langkah 3.2 yaitu pilih dua node terkecil dan gabungkan keduanya. Node(BD,2) dan node(C,2) adalah node yang terkecil maka di gabungkan menjadi node(BDC,4) kemudian diurutkan bersama node yang lain



3.4 Ulangi langkah diatas sampai terbentuk node akar



3.5 Beri bit 0 pada node yang merupakan anak kiri dan bit 1 pada node yang merupakan anak kanan. Hal ini dilakukan terhadap semua node kecuali terhadap node akar. Maka akan diperoleh tree berikut ini:



Jika dilihat dari pohon diatas maka encoding String "ABCACAD" dengan aturan jika berjalan ke kiri = 0 dan kekanan = 1, maka akan menjadi seperti ini

A = 0 B = 100 C = 11 D = 101

Algoritma Huffman diatas mengakibatkan data yang kirim menjadi kecil, yaitu :

0 100 11 0 11 0 101 = 13 bit
 A B C A C A D

Dan isi dari file tersebut sudah di enkripsi menjadi

4
 njh
 A1: C2: B3: D3:
 i
 5

HASIL DAN PEMBAHASAN

Proses enkripsi dan deskripsi suatu file dengan algoritma Huffman di implementasikan dalam bahasa python versi 2.7.

Algoritma program untuk enkripsi secara garis besar sebagai berikut:

- Baca karakter apa saja yang di gunakan dalam file yang akan di mampatkan dan berapa kali masing-masing karakter digunakan (Frekuensi). Kemudian buat node-node untuk masing-masing pasangan(karakter, frekuensi)
- Pohon Huffman di buat
- Berilah tanda 0 atau 1 untuk pengkodeannya
- Baca ulang file tersebut dan terjemahkan dalam kode yang telah dibuat, hasil terjemahan tersebut disimpan dalam file. File ini adalah file yang telah dimampatkan.

Algoritma program untuk membaca kembali file yang telah dienkrpsi

- Baca tanda pengenalan dan table kode
- Huffman Tree dibuat dari table kode tersebut
- Baca data dan langsung diterjemahkan ke bentuk aslinya, hasil terjemahan tersebut disimpan dalam file

Program asli diambil dari Nick Jones dan Josh Davis's CS 201 course at Carleton College, November 2010. dan di tulis ulang untuk penulisan ini.

Nama dan manfaat masing-masing fungsi utama dalam Huffman.py

1. Fungsi main

Fungsi utama dalam Huffman.py. Untuk menjalankan aplikasi ini digunakan perintah `python huffman.py [compress/decompress] [filename]` dimana untuk argumen "compress" untuk mengenkripsi dan memampatkan file dan argumen decompress untuk membuka kembali menjadi file asal..

```
if __name__ == "__main__":
    if sys.argv[1] == 'compress':
        encode(sys.argv[2])
    elif sys.argv[1] == 'decompress':
        decode(sys.argv[2])
    else:
```

```
print 'Salah Memasukkan data.: huffman.py [decode/encode] [filename]'
```

2. Fungsi ENCODE

Berguna untuk mengenkripsi file dan menghitung frekuensi untuk setiap karakter yang dibaca serta membuat pohon Huffman. Hasil file yang di enkripsi adalah Namafile+'Compressed.txt'

```
def encode(fileName):

    try:
        wholeDoc = open(fileName, 'r')
    except IOError:
        print 'File Salah'
        return
    docStr = wholeDoc.read()

    allNodes = createHuffmanNodes(docStr)
    tree = createTree(allNodes)
    tree.parseCodeWords(tree.getRoot())
    codeWordDict = tree.getCodeWords()

    (chars, charsBin) = tree.writeFile(docStr)
    compressedSize = len(chars)/1024.0
    originalSize = tree.getRoot().getWeight()/1024.0

    # write the file:
    outFile_name = fileName[:len(fileName) - 4] + 'Compressed.txt'

    f = open(outFile_name, 'w')
    f.write(chars)
    print Selesai. Nama File hasil adalah :, outFile_name
    print 'Original:', originalSize, 'KB;', 'Compressed:', compressedSize, 'KB'
    print 'Compression rate of', compressedSize/originalSize
```

3. Fungsi DECODE

Berguna untuk mengubah ke bentuk asal dari file. Hasil file adalah NamaFile + 'decompressed.txt'.

```
def decode(fileName):
    (rebuiltDict, truncatedFileStr) = importDict(fileName)
    if (rebuiltDict, truncatedFileStr) != (None, None):
        tree = HuffmanTree()
        tree.setCodeWords(rebuiltDict)
        reconstructed = tree.decodeFile(truncatedFileStr)
        outFile_name = fileName[:fileName.index('Compressed.txt')]
        outFile_name += 'Decompressed.txt'
        f = open(outFile_name, 'w')
        f.write(reconstructed)

    print 'Done. Your decompressed file is saved as:', outFile_name
```

Uji Coba Aplikasi

Nama file : uji.txt

Isi dari file uji.txt

Algoritma Huffman

C:\Python27>python huffman.py compress uji1.txt

Isi dari file uji1Compressed.txt

15

njh

A4: 4: g4: f4:


```
i4:H4:-  
4:m3: l4:  
o4:n4: r4:  
u4:  
t4a4:  
'8¥Á"×p6{1 2
```

```
C:\Python27>python huffman.py decompress uji1Compressed.txt
```

```
Directory of C:\Python27
```

```
09/25/2013 05:07 PM          21 Uji1.txt  
09/25/2013 05:07 PM          82 uji1Compressed.txt  
09/25/2013 05:08 PM          21 uji1Decompressed.txt  
                3 File(s)          124 bytes  
                0 Dir(s)  2,019,008,512 bytes free
```

```
Nama File LICENSE.txt  
Isi dari File : lihat lampiran
```

```
C:\Python27>python huffman.py compress LICENSE.txt  
Isi dari file LICENSECompressed.txt { Lihat Lampiran )  
85  
njh  
15:  
6:2 2: "9:%o $14:'
```

```
Directory of C:\Python27
```

```
05/15/2013 10:53 PM          40,098 LICENSE.txt  
09/25/2013 05:12 PM          25,988 LICENSECompressed.txt  
                2 File(s)          66,086 bytes  
                0 Dir(s)  2,018,983,936 bytes free
```

```
C:\Python27>python huffman.py decompress LICENSECompressed.txt
```

```
Traceback (most recent call last):
```

```
File "huffman.py", line 150, in <module>
```

```
    decode(sys.argv[2])
```

```
File "huffman.py", line 42, in decode
```

```
    reconstructed = tree.decodeFile(truncatedFileStr)
```

```
File "C:\Python27\huffmantree.py", line 85, in decodeFile
```

```
    lastCharBin = '0'*(int(lastTwoChars[1]) - len(lastCharBin)) + lastCharBin #
```

```
lastTwoChars[1] tells how long bin. rep. of lastChar should be.
```

```
ValueError: invalid literal for int() with base 10: 'o'
```

KESIMPULAN

Aplikasi ini dibuat untuk pembelajaran tentang kriptografi yang sederhana. Dalam uji coba dibuat kesimpulan

File yang isinya mempunyai karakter berfrekuensi satu(tidak ada karakter yang sama) atau isinya lebih kecil dari pada tabel kode yang dibuat hasil file yang dimampatkan lebih besar dari file asli.

File hasil enkripsi yang lebih besar dari 1KB maka tidak dapat di deskripsi /dikembalikan ke bentuk aslinya.

Tidak adanya kunci (key) untuk deskripsi file membuat isi file mudah untuk dibaca bagi yang tidak berhak jika mempunyai program algoritma Huffman.

File asli tidak di hapus karena aplikasi ini untuk pembelajaran tentang kriptografi

Isi File telah dapat di samarkan / di kodekan sehingga tidak mudah dibaca

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```

# HUFFMAN.PY

from huffmantreenode import HuffmanTreeNode
from queue import Queue
from huffmantree import HuffmanTree
import sys

def encode(fileName):
    """Takes in a fileName, creates a HuffmanTree and compresses the original file based on this tree."""
    try:
        wholeDoc = open(fileName, 'r')
    except IOError:
        print 'Invalid filename. Make sure your file is in same directory as this program.'
        return
    docStr = wholeDoc.read()

    allNodes = createHuffmanNodes(docStr)
    tree = createTree(allNodes)
    tree.parseCodeWords(tree.getRoot())
    codeWordDict = tree.getCodeWords()

    (chars, charsBin) = tree.writeFile(docStr)
    compressedSize = len(chars)/1024.0
    originalSize = tree.getRoot().getWeight()/1024.0

    # write the file:
    outFile_name = fileName[:-len(fileName) - 4] + 'Compressed.txt'

    f = open(outFile_name, 'w')
    f.write(chars)
    print 'Done. Your compressed file is saved as:', outFile_name
    print 'Original:', originalSize, 'KB;', 'Compressed:', compressedSize, 'KB'
    print 'Compression rate of', compressedSize/originalSize

def decode(fileName):
    """Takes in a file name, rebuilds dictionary and writes the decompressed file."""
    (rebuiltDict, truncatedFileStr) = importDict(fileName)
    if (rebuiltDict, truncatedFileStr) != (None, None):
        tree = HuffmanTree()
        tree.setCodeWords(rebuiltDict)
        reconstructed = tree.decodeFile(truncatedFileStr)
        outFile_name = fileName[:-len(fileName).index('Compressed.txt')]
        outFile_name += 'Decompressed.txt'
        f = open(outFile_name, 'w')
        f.write(reconstructed)

        print 'Done. Your decompressed file is saved as:', outFile_name

def createHuffmanNodes(docStr):
    """Reads string of entire document (docStr) and returns a dictionary of form: individual character -> HuffmanNode for that char"""
    results = {}
    for x in docStr: # increment weight, else create a new node with weight 1
        try:
            temp = results[x]
            temp.setWeight(temp.getWeight() + 1)
        except KeyError:
            results[x] = HuffmanTreeNode(1, x)
    return results

def createTree(allNodes):
    """Takes in dictionary of Huffman nodes. Creates a Huffman Tree based on each node's frequencies."""
    listNodes = allNodes.values()
    listNodes.sort(compareHuffNodes)

    singleNodes = Queue() # will contain all HTNodes at first
    comboNodes = Queue() # will contain trees - nodes with others hanging off
    while len(listNodes) > 0:
        singleNodes.enqueue(listNodes.pop(0)) # these will be sorted with least weight at front

```

```

while len(singleNodes) + len(comboNodes) > 1:
    i = 0
    temp = [None, None]
    for i in range(2): # tiny for loop saves code!

        singleNodeWeight = None
        comboNodeWeight = None
        if singleNodes.peek() != None:
            singleNodeWeight = singleNodes.peek().getWeight()
        if comboNodes.peek() != None:
            comboNodeWeight = comboNodes.peek().getWeight()

        if singleNodeWeight == None:
            temp[i] = comboNodes.dequeue()
        elif comboNodeWeight < singleNodeWeight and comboNodeWeight != None:
            temp[i] = comboNodes.dequeue()
        else: # they can't both be None, so no need to check if singleNodeWeight is None
            temp[i] = singleNodes.dequeue()

    parent = HuffmanTreeNode()
    parent.setLeftChild(temp[0])
    parent.setRightChild(temp[1])
    comboNodes.enqueue(parent)

root = comboNodes.dequeue() # should only be one left

tree = HuffmanTree(root)
return tree

def importDict(fileName):
    """Rewrites the dictionary of key value pairs based on the first few lines of compressed file."""
    rebuiltDict = {}
    try:
        f = open(fileName, 'r')
    except IOError:
        print 'Invalid filename. Make sure your file is in same directory as this program.'
        return (None, None)
    numEntries = int(f.readline())

    if f.readline() != '\n':
        print 'maybe this isn\'t a file compressed by NJ Huffman'
    entryNum = 0
    while entryNum < numEntries:

        tempchar = f.read(1)
        temp = f.read(1) # start of length of codeword
        length = ""
        while temp != '!':
            length += temp
            temp = f.read(1)

        length = int(length)
        binStr = ""
        i = 0
        for i in range(length/8):
            encodedChar = f.read(1)
            tempBinStr = bin(ord(encodedChar))[2:] # don't want the '0b'
            binStr += tempBinStr.zfill(8) # char => binary => add zeros to make length 8
        if length % 8 != 0: # there's an extra char left to read
            encodedChar = f.read(1)
            tempBinStr = bin(ord(encodedChar))[2:] # don't want the '0b'
            binStr += tempBinStr.zfill(length % 8) # char => binary => add zeros to make length = length % 8

        rebuiltDict[tempchar] = binStr
        entryNum += 1
    return (rebuiltDict, f.read())

def compareHuffNodes(node1, node2):

```

```

        """Compares two Huffman nodes by weight"""
        if node1.getWeight() < node2.getWeight():
            return -1
        else:
            return 1

if __name__ == "__main__":
    if sys.argv[1] == 'compress':
        encode(sys.argv[2])
    elif sys.argv[1] == 'decompress':
        decode(sys.argv[2])
    else:
        print 'Invalid input. Please enter in the form: huffman.py [decode/encode] [filename]'

*-----
#HuffmannTree.py

from huffmantreenode import HuffmanTreeNode

class HuffmanTree(object):

    def __init__(self, root = None):
        """Creates a new instance of a Huffman tree. The root is the HuffmanTreeNode at the top of the entire tree. """
        self.root = root
        self.codeWords = {} # of form char => binary string

    def parseCodeWords(self, currentNode, currentCode = ""):
        """Traverses the tree, populating the dictionary with characters and their cooresponding codewords."""
        if currentNode == None: # i.e. parent was a leaf node
            return
        else:
            if currentNode.getValue() != None: # we don't want branch nodes in our dictionary
                self.codeWords[currentNode.getValue()] = currentCode

            self.parseCodeWords(currentNode.getLeftChild(), currentCode + '0') # set left to be currentCode + '0'
            self.parseCodeWords(currentNode.getRightChild(), currentCode + '1') # set right to be currentCode + '1'

    def getCodeWords(self):
        """Returns dictionary with character keys and codeword values."""
        return self.codeWords

    def setCodeWords(self, dict):
        """For rebuilding. Program will read in representation of codeWords dictionary, set codeWords equal to it."""
        self.codeWords = dict

    def getRoot(self):
        """Returns root of this HuffmanTree"""
        return self.root

    def writeFile(self, doc):
        """Returns a string in binary form of the inputted string doc, and the ASCII equivalent of the binary string,
        which will be written to the compressed file. Uses the codeWord dictionary to convert from characters to binary digits"""

        binStr = self.convertToBinary(doc)
        encodedStr = self.getDictRep() # this will add the dictionary to start of compressed file
        i = 0
        while i < len(binStr) - 8: # change binary reps. to characters. Must stop before the end, because string length
            # isn't necessarily divisble by 8. Last chunk will probably not be 8 long.
            temp = chr(int(binStr[i:i+8], 2))
            encodedStr += temp
            i += 8

        lastLength = len(binStr[i:]) # how many left over are there?
        encodedStr += chr(int(binStr[i:], 2)) + str(lastLength) # add the ascii of last few bits, and how many bits that is
        return (encodedStr, binStr)

    def getDictRep(self):
        """Returns a string representation of the codeWords dictionary to be written to compressed file."""

```

```

fullStr = str(len(self.codeWords)) + '\nnjh\n'
for char in self.codeWords:
    binStr = self.codeWords[char]
    encodedStr = char + str(len(binStr)) + ':'
    i = 0
    while i < len(binStr) - 8: # change binary reps. to characters. Must stop before the end, because
string length isn't necessarily divisible by 8. Last chunk will probably not be 8 long.
        temp = chr(int(binStr[i:i+8], 2))
        encodedStr += temp
        i += 8

    encodedStr += chr(int(binStr[i:], 2)) # add the ascii of last few bits, and how many bits whole string is
    fullStr += encodedStr
return fullStr

def convertToBinary(self, originalDoc):
    """Converts originalDoc to binary string based on HuffmanTree"""
    binStr = ""
    for x in originalDoc:
        binStr += self.codeWords[x]
    return binStr

def decodeFile(self, doc):
    """Takes in the twice encoded file (i.e. the ascii characters of the original binary code). Decodes to binary and
eventually to original text. Should only be called once the tree has been rebuilt."""
    binStr = ""
    lastTwoChars = doc[len(doc) - 2:] # Last two characters are important. Last one tells us how many bin. digits
the second to last one should have when changed to binary representation.
    adjustedDoc = doc[:len(doc) - 2]
    for character in adjustedDoc:
        temp = bin(ord(character))[2:] # strip '0b'
        extraSpace = 8 - len(temp) # this number indicates how many zeros should be added at front of temp
(so that it is of length 7)
        zeros = '0'*extraSpace
        temp = zeros + temp
        binStr += temp

    lastCharBin = bin(ord(lastTwoChars[0]))[2:] # just like for all the others
    lastCharBin = '0'*(int(lastTwoChars[1]) - len(lastCharBin)) + lastCharBin # lastTwoChars[1] tells how long bin.
rep. of lastChar should be.
    binStr += lastCharBin

    toReturn = self.binToOriginal(binStr)
    return toReturn

def binToOriginal(self, binStr):
    """Takes in binary string of digits, converts them to text based on the codeWords dictionary"""
    reverseDir = {}
    for x in self.codeWords:
        reverseDir[self.codeWords[x]] = x
    begIndex = 0
    curIndex = 0
    rebuiltStr = ""
    while curIndex < len(binStr) + 1:
        try:
            rebuiltStr += reverseDir[str(binStr[begIndex:curIndex])] # try looking up current digit
string in dict
            begIndex = curIndex # if it worked, move the beginning index to the end of last chunk
        except KeyError:
            curIndex += 1 # move along if current digit string was not found in dictionary
    return rebuiltStr

```

```

*-----
# HuffmanTreeNode.py

from binarytreenode import BinaryTreeNode

class HuffmanTreeNode(BinaryTreeNode):
    """A subclass of BinaryTreeNode. Acts in exact same manner as BTN except has an extra instance variable, weight, which
    stores the frequency of the instance variable value. Interior nodes' weight is the sum of all of its children. Nodes DO NOT KNOW
    THEIR OWN CODE! This is instead dealt with by another class, HuffmanTree, which contains a pointer to the root node and deals
    with the codewords."""

    def __init__(self, weight=0, value=None):
        """Initializes a new Huffman tree node with given weight and value (though interior nodes will have value
        None) """
        BinaryTreeNode.__init__(self,value)
        self.weight = weight

    def setWeight(self, newWeight):
        """Sets this node's weight to newWeight. Useful for interior nodes."""
        self.weight = newWeight

    def getWeight(self):
        """Returns this node's weight """
        return self.weight

    def setLeftChild(self, node):
        """Sets left child to given node, which will presumably be a HTN."""
        BinaryTreeNode.setLeftChild(self, node)
        self.weight += node.getWeight()

    def setRightChild(self, node):
        """Sets right child to given node, which will presumably be a HTN."""
        BinaryTreeNode.setRightChild(self, node)
        self.weight += node.getWeight()

    def __str__(self):
        """Returns a string representation - empty child is []. Easier to rewrite this method than to call it from superclass
        and alter it then."""
        if self.left == None:
            leftStr = '[]'
        else:
            leftStr = str(self.left)

        if self.right == None:
            rightStr = '[]'
        else:
            rightStr = str(self.right)

        if self.value == None:
            valStr = 'None'
        else:
            valStr = str(self.value)
        return '[' + valStr + ', ' + str(self.weight) + '], ' + leftStr + ', ' + rightStr + ']'

if __name__ == "__main__":
    n = HuffmanTreeNode(12, 'a')
    m = HuffmanTreeNode(13, 'd')
    parent = HuffmanTreeNode()
    parent.setLeftChild(n)
    parent.setRightChild(m)
    print 'm: ', m
    print 'n: ', n
    print 'parent:', parent

```



```

*-----
# LinkedListNode.py
class LinkedListNode(object):
    """A basic linked list node class, for use in implementing other more interesting classes."""

    def __init__(self, data):
        """Initializes a new node with the given data and no next node."""
        self.data = data
        self.next = None

    def setData(self, data):
        """Sets the node's data, which is set for the first time in __init__()."""
        self.data = data

    def getData(self):
        """Returns the data currently stored in the node."""
        return self.data

    def setNext(self, next):
        """Sets the next node, which is None by default."""
        self.next = next

    def getNext(self):
        """Returns the next node, or None."""
        return self.next

    def __str__(self):
        """Returns data as string"""
        return self.data

if __name__ == "__main__":
    node = LinkedListNode('hello')
    node2 = LinkedListNode('bye')
    node3 = LinkedListNode('later')
    node.setNext(node2)
    node2.setNext(node3)

    temp = node
    while temp != None:
        print str(temp)
        temp = temp.getNext()

*-----
# queue.py

from linkedlistnode import LinkedListNode

class Queue(object):
    """A queue, similar to the one in our Miller and Ranum textbook."""

    def __init__(self):
        """Initializes an empty queue."""
        self.front = None
        self.back = None
        self.count = 0

    def enqueue(self, x):
        """Puts the given object into the queue, at the back."""
        if self.count == 0:
            self.front = LinkedListNode(x)
            self.back = self.front
        else:
            temp = LinkedListNode(x)
            self.back.setNext(temp)
            self.back = temp
        self.count += 1

    def dequeue(self):
        """If the queue is not empty, then removes the front object and returns it. If the queue is empty, then does
nothing and returns None."""

```

```

        if self.count == 0:
            return None
        else:
            temp = self.front.getData()
            self.front = self.front.getNext()
            if self.count == 1:
                self.back = None
            self.count -= 1
            return temp

    def peek(self):
        """If the queue is not empty, then returns the front object, without removing it from the queue. If the queue is
empty, then returns None."""
        if self.front == None:
            return None
        else:
            return self.front.getData()

    def __len__(self):
        """Returns the number of objects in the queue."""
        return self.count

    def __str__(self):
        """Returns a human-readable string representation of the queue, from front to back, assuming that the objects in
the queue themselves respond to the __str__ method."""
        if self.count == 0:
            return ""
        elif self.count == 1:
            return "(" + str(self.front.getData()) + ")"
        else:
            # There are at least two objects; commas are needed.
            string = "(" + str(self.front.getData())
            current = self.front.getNext()
            while current != None:
                string += ", " + str(current.getData())
                current = current.getNext()
            string += ")"
            return string

# If this file was executed (rather than imported), then run this demo.
if __name__ == "__main__":
    myQueue = Queue()
    print myQueue
    myQueue.enqueue("Jill")
    print myQueue
    myQueue.enqueue("John")
    print myQueue
    print myQueue.getSize()
    print myQueue.dequeue()
    print myQueue
    myQueue.enqueue(2.0 * 3.14159)
    print myQueue
    myQueue.enqueue("Jenny")
    print myQueue
    print myQueue.dequeue()
    print myQueue
    print myQueue.dequeue()
    print myQueue
    print myQueue.dequeue()
    print myQueue
    print myQueue.dequeue()
    print myQueue

```

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A. HISTORY OF THE SOFTWARE

Python was created in the early 1990s by Guido van Rossum at Stichting Mathematisch Centrum (CWI, see <http://www.cwi.nl>) in the Netherlands as a successor of a language called ABC. Guido remains Python's principal author, although it includes many contributions from others.

In 1995, Guido continued his work on Python at the Corporation for National Research Initiatives (CNRI, see <http://www.cnri.reston.va.us>) in Reston, Virginia where he released several versions of the software.

In May 2000, Guido and the Python core development team moved to BeOpen.com to form the BeOpen PythonLabs team. In October of the same year, the PythonLabs team moved to Digital Creations (now Zope Corporation, see <http://www.zope.com>). In 2001, the Python Software Foundation (PSF, see <http://www.python.org/psf/>) was formed, a non-profit organization created specifically to own Python-related Intellectual Property. Zope Corporation is a sponsoring member of the PSF.

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1.6.1	1.6	2001	CNRI	yes (2)
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2.1.2	2.1.1	2002	PSF	yes
2.1.3	2.1.2	2002	PSF	yes
2.2.1	2.2	2002	PSF	yes
2.2.2	2.2.1	2002	PSF	yes

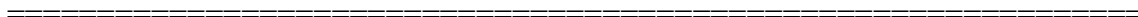
2.2.3	2.2.2	2003	PSF	yes
2.3	2.2.2	2002-2003	PSF	yes
2.3.1	2.3	2002-2003	PSF	yes
2.3.2	2.3.1	2002-2003	PSF	yes
2.3.3	2.3.2	2002-2003	PSF	yes
2.3.4	2.3.3	2004	PSF	yes
2.3.5	2.3.4	2005	PSF	yes
2.4	2.3	2004	PSF	yes
2.4.1	2.4	2005	PSF	yes
2.4.2	2.4.1	2005	PSF	yes
2.4.3	2.4.2	2006	PSF	yes
2.4.4	2.4.3	2006	PSF	yes
2.5	2.4	2006	PSF	yes
2.5.1	2.5	2007	PSF	yes
2.5.2	2.5.1	2008	PSF	yes
2.5.3	2.5.2	2008	PSF	yes
2.6	2.5	2008	PSF	yes
2.6.1	2.6	2008	PSF	yes
2.6.2	2.6.1	2009	PSF	yes
2.6.3	2.6.2	2009	PSF	yes
2.6.4	2.6.3	2009	PSF	yes
2.6.5	2.6.4	2010	PSF	yes
2.7	2.6	2010	PSF	yes

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Julian Seward, jseward@bzip.org
bzip2/libbzip2 version 1.0.6 of 6 September 2010

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