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 chipertext.
Proses kebalikan enkripsi, yaitu mengubah chipertext 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 asliny. Dalam penulisan ini Algoritma Huffman digunakan untuk mengekripsi / 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, sehigga 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

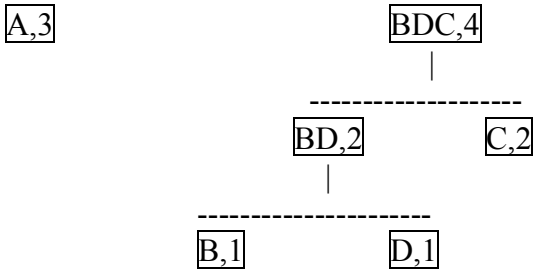
2. Frekuensi tersebut di urutkan makin naik sebagai berikut
   B D C A
   1 1 2 3

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

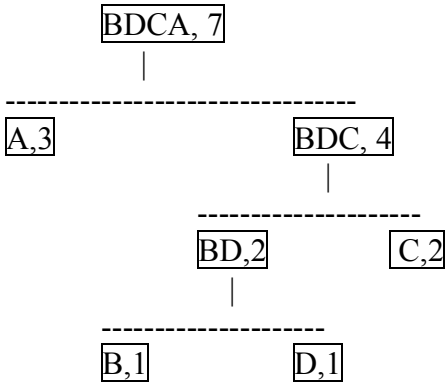
3.1 Buat 4 node untuk masing-masing pasangan yaitu Karakter, Frekuensi

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).

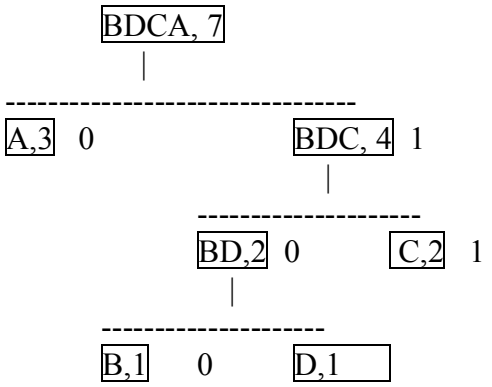
3.3 Ulangi langkah 3.2 yaitu pilih dua node terkecil dan gabungkan keduanya. Node(BD,2) dan node(C,2) adalah node yang terkecil maka di gabungkan menjadi node(BDC,4) kemudian diurutkan bersama node yang lain



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 makan 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 fle 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 1untuk 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 dienkripsi

- Baca tanda pengenal 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:
    outFileName = fileName[:len(fileName) - 4] + 'Compressed.txt'

    f = open(outFileName, 'w')
    f.write(chars)
    print Selesai. Nama File hasil adalah :', outFileName
    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)
        outFileName = fileName[:fileName.index('Compressed.txt')]
        outFileName += 'Decompressed.txt'
        f = open(outFileName, 'w')
        f.write(reconstructed)

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

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¨×þ6{┐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:‰ $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:
	outFileName = fileName[:len(fileName) - 4] + 'Compressed.txt'

	f = open(outFileName, 'w')
	f.write(chars)
	print 'Done. Your compressed file is saved as:', outFileName
	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)
		outFileName = fileName[:fileName.index('Compressed.txt')]
		outFileName += 'Decompressed.txt'
		f = open(outFileName, 'w')
		f.write(reconstructed)

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

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() != 'njh\n':
		print 'maybe this isn\'t a file comprresed 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 divisble 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 orignial 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.

All Python releases are Open Source (see http://www.opensource.org for the Open Source Definition). Historically, most, but not all, Python releases have also been GPL-compatible; the table below summarizes the various releases.

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0.9.0 thru 1.2		1991-1995	CWI	yes
1.3 thru 1.5.2	1.2	1995-1999	CNRI	yes
1.6	1.5.2	2000	CNRI	no
2.0	1.6	2000	BeOpen.com	no
1.6.1	1.6	2001	CNRI	yes (2)
2.1	2.0+1.6.1	2001	PSF	no
2.0.1	2.0+1.6.1	2001	PSF	yes
2.1.1	2.1+2.0.1	2001	PSF	yes
2.2	2.1.1	2001	PSF	yes
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
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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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