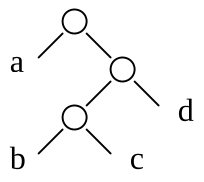
CSE 373
Autumn 2002
Project 2
Due Wednesday, November 13, 2002, 11:30 pm

Introduction

One of the most important lossless data compression algorithms is called Huffman coding. A Huffman code is defined by a tree, whose leaves are the symbols in the alphabet. For example, the tree



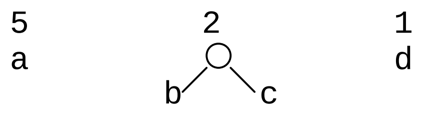
If we indicate going left by 0 and going right by 1, then the Huffman code for the above tree is:

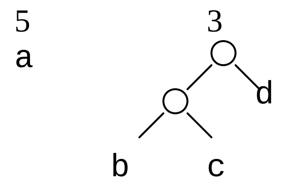
a	0
b	100
c	101
d	11

A string of symbols aadbaaca would be encoded as 0011100001010. This would yield compression considering the original requires 8 bits per symbol. So 64 bits have been reduced to 13 bits. The reason we get compression is that the symbol “a” occurs quite frequently in the original and the Huffman code uses just one bit to encode it. There is a simple process to decoding a Huffman code. Start at the root of the tree. If you are at a leaf output the symbol. Otherwise read a bit and go left if is 0 and go right if is 1 and continue in that manner until reaching a leaf. An *optimal Huffman* code is one that produces the shortest code given frequencies for the symbols.

It turns out there is an elegant algorithm for generating an optimal Huffman code. The algorithm uses a priority queue. First you need to calculate the frequency of each symbol in the input. Make a leaf node for each symbol and store its frequency in the node. Repeatedly do the following, find the two trees with the smallest frequencies. Make them the left and right children of a new node whose frequency the sum of the two frequencies. When one tree remains we are done. In the example above the frequencies are a:5, b:1, c:1, d:1.

```
5    1    1    1
a    b    c    d
```





In one more step we are done. The average bit rate of the code can be computed as

$$ABR = (F_1L_1 + F_2L_2 + \dots + F_mL_m)/N$$

where F_i is the frequency of the i'th symbol, L_i is the length of the code for the i'th symbol and N is the length of the file. Without actually compressing the file the compression ratio for a text file can be computed as 8/ABR. This is because the uncompressed tex file is stored with 8 bits per symbol.

The goal in this project is to use predefined priority queues to build an optimal Huffman tree. Your priority queue will maintain the current set of trees ordered by their frequencies. One challenge is to efficiently traverse the optimal Huffman tree to generate the code to be printed out.

The User Interface

Again we are not too concerned with the user interface because we are working with the data structures. The program requests a text file name, then computes the optimal Huffman code and prints it. The compression ratio is then printed.

```
> Please enter a text file name:
foo.txt
> The optimal Huffman code is:
> a  0
> b  100
> c  101
> d  11
> The compression ratio is:
> 4.92
```

Your program should check for invalid inputs.

What Code you can Use

Professor Weiss has a web page that include codes for Binary Heaps (priority queue). You should use that code as part of your project.

Source Code for Data Structures and Algorithm Analysis in Java

Source Code for Data Structures and Algorithm Analysis in C++ (Second Edition)

If you are working in C++ you should use the I/O library found here:

http://www.redhat.com/docs/manuals/gnupro/GNUPro-Toolkit-00r1/4_libs/c_The_GNU_C++_Iostream_Library/libio.html

In particular, the link "Operators and Default Streams" from the above page will be of most use and allow you to see the key read/write routines with an example. The rest is probably excessive detail.

If you are working in Java then you'll want to use one of the I/O libraries found in

http://www.cs.washington.edu/education/courses/143/02au/javaLibraries.html

which is local to UW. You may also use the standard package java.io found in at the Sun web site

http://java.sun.com/j2se/1.4.1/docs/api/java/io/package-summary.html

Tree drawing

To debug your program you may want to use Graphviz which draws trees and other graphs. The Graphviz information page is available at

http://www.research.att.com/sw/tools/graphviz/.

The Graphviz program "dot" generates output in Postscript format. There are many viewers available for Postscript. I recommend GSview with Ghostscript on Windows machines. The home page for GSview is http://www.cs.wisc.edu/~ghost/gsview/ where you will find the latest revision information for both GSview and Ghostscript.

How to Turn in your Program

The web based turn-in will be announced when a few days before the due date.

Good Luck!