CS 111 Design Problem

Laboratory 1 – Tab Completion

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# Introduction

For our design problem, we decided to explore how to further emulate the *bash* shell. We will observe that behavior of tab completion in order to define a plan for extending our own *ospsh* shell. The feature we will be observing tab completion.

We will also explore the functionality of the GNU readline library. According to the description, this library can be used to display a prompt and receive the entered string from the user. In addition, the library provides emacs style bindings to the user. This allows the user to use shortcuts such as ctrl + e to get to the end of a line and ctrl + u to delete a line.

## Tab Completion

One of the most widely used features of *bash* is tab completion. This feature allows the user to press the tab key to automatically display and complete a list of commands that match the current inputted string. For example, a user would start typing in “ssh” if they wanted to execute the command “ssh-keygen”. After initially typing this in, the user would then be able to type the tab key. On the line below the current line, a list of matched commands are printed out. For this example, “ssh”, “ssh-agent”, and “ssh-keygen” are all commands that would be printed out.

This also allows the user to finish

## Binary Search Tree

While other data structures could be used in our implementation, we decided to implement a binary search tree. A binary search tree is a dynamically allocate structure that is guaranteed to be sorted. It is easy to insert new entries into it, and does not require shifting of items. All it requires is allocation of a new node and inserting it into its proper place.

While an array or a linked list were choices four our data structure, we ultimately decided to implement a binary search tree.

|  |  |  |  |
| --- | --- | --- | --- |
| Feature | Dynamic Array | Linked List | Binary Search Tree |
| Adding (allocation) | Would only need to use realloc if not enough space. Otherwise just insert element | Need to allocate enough memory for a new node | Need to allocate enough memory for a new node |
| Add (sorting) | The keep elements in order, we would need to shift elements in the array over | Sorting built in to the algorithm used to insert; would have to traverse the whole linked list; Worse case O(N) | Sorting built in to the algorithm used to insert; Ideal worse case O(NlogN) if the tree is balancing |
| Overhead (extra bytes besides string) | None; the string would be the only variable stored | 4 bytes; we need a pointer to the next node | 8 bytes; we need pointers to the left and right children |

# Design / Implementation Details

In our implementation, we will be expanding off the current lab 1. We will be adding two files to our project: tab\_completion.h and tab\_completion.c. The tab\_completion file will handle the data structure and its functions, as well as the requirements for *readline*. We will discuss the details of our implementation plan in this section.

## Adding Readline

### Related files:

main-b.c

### Related Functions:

char \*readline (const char \*prompt);

char \*fgets (char \*str, int num, FILE \*stream);

### Implementation:

The first thing we need to do to implement tab completion is to introduce the *readline* function into our existing main. Currently, the function *fgets* is being used to retrieve input from the keyboard. In addition, the way *readline* works is different compared to how *fgets* works. The *readline* function allocates memory for a string and returns it while *fgets* takes the pointer to an existing buffer as well as its size and writes into it.

To implement this, we need to create a char \* variable. We can then set this variable to the return value of *readline*. If the return value is equal to NULL, then we should exit because then EOF was returned. Otherwise, we should use the return value and put it through the existing operations. Also, it is important to free the string at the end of the iteration.

## Storing commands

### Related files:

tab\_completion.h / tab\_completion.c

### Related Variable:

pathcommand\_t \*HEAD;

### Related Struct:

typedef struct pathcommand pathcommand\_t;

//Define a node for our BST

struct pathcommand {

char \*cmd;

pathcommand\_t \*left;

pathcommand\_t \*right;

};

### Related Functions:

pathcommand\_t \*pathcommand\_alloc(void); //alloc

void pathcommand\_free(pathcommand\_t \*pathcmd); // free

void add\_pathcommand(char \*cmd);

void print\_tree(void); // only used for debugging

### Implementation:

First, we will strictly explain how we will build our data structure. If we want to build a binary search tree, then we will have to create a node struct. That is precisely what pathcommand\_t is. The data value for our struct is char \*cmd. In addition, we will create a pathcommand\_t \*HEAD as a global variable since we will only have one tree. We can reference this as our head pointer for the binary search tree.

Our design requires us to create a function to add pathcommand\_t ‘s, but not to remove. As a result, we should create a command that adds a pathcommand to the tree. We can call a recursive helper function to add the new command to the tree.

## Finding commands

### Related files:

tab\_completion.h / tab\_completion.c

### Related Struct:

struct dirent { // d\_name is the only important member of this struct

char d\_name[255 + 1];/\* name must be no longer than this \*/

};

### Related Functions:

char \*getenv(const char \*name);

DIR \*opendir(const char \*dirname);

struct dirent \*readdir(DIR \*dirp);

int closedir(DIR \*dirp);

void initialize\_path\_tree(void);

### Implementation:

Our approach here is to populate a list of all the commands when our program starts. We will write the function initialize\_path\_tree to accomplish this task. Our algorithm will be simple:

Replace with a diagram?

1. Add all our special commands to the BST (e.g. cd, exit, makeq…)
2. Go through each directory in your PATH
   1. Open the directory
   2. Iterate through the items in the directory
      1. If the item is not “.” Or “..”
         1. Add it to the BST
   3. Close the directory

## Integrating with readline

### Related files:

tab\_completion.h / tab\_completion.c / main-b.c

### Related Functions:

### Implementation:

The first thing we need to do to implement tab completion is to introduce the readline function into our

# Results

# Conclusion

### Tab Completion

### Other Random Features