System Programming CSE25101
Coding Project #4. Writing Your Own Unix Shell

Introduction

The purpose of this assignment is to become more familiar with the concepts of process control. You will do this by writing a simple Unix shell program that supports job control.

What to do and submit

Looking at the `tsh.c` (*tiny shell*) file, you will see that it contains a functional skeleton of a simple Unix shell. To help you get started, we have already implemented the less interesting functions. Your assignment is to complete the remaining empty functions listed below. As a sanity check for you, we've listed the approximate number of lines of code for each of these functions in our reference solution (which includes lots of comments.)

> `eval`: Main routine that parses and interprets the command line. [70 lines]
>
> `builtin_cmd`: Recognizes and interprets the built-in commands: `quit`, `fg`, `bg`, and `jobs`. [25 lines]
>
> `waitfg`: Waits for a foreground job to complete. [20 lines]

Each time you modify your `tsh.c` file, type `make` to recompile it. To run your shell, type `tsh` to the command line:

```
unix> ./tsh
tsh> [type commands to your shell here]
```

General Overview of Unix Shells

A *shell* is an interactive command-line interpreter that runs programs on behalf of the user. A shell repeatedly prints a prompt, waits for a *command line* on `stdin`, and then carries out some action, as directed by the contents of the command line.

The command line is a sequence of ASCII text words delimited by whitespace. The first word in the command line is either the name of a built-in command or the pathname of an executable file. The remaining words are command-line arguments. If the first word is a built-in command, the shell immediately executes the command in the current process. Otherwise, the word is assumed to be the pathname of an executable program. In this case, the shell forks a child process, then loads and runs the program in the context of the child. The child processes created as a result of interpreting a single command line are known collectively as a *job*. In general, a job can consist of multiple child processes connected by Unix pipes.

If the command line ends with an ampersand "&", then the job runs in the *background*, which means that the shell does not wait for the job to terminate before printing the prompt and awaiting the next command line. Otherwise, the job runs in the *foreground*, which means that the shell waits for the job to terminate before awaiting the next command line. Thus, at any point in time, at most one job can be running in the

foreground. However, an arbitrary number of jobs can run in the background.

For example, typing the command line

```
tsh> jobs
```

causes the shell to execute the built-in `jobs` command. Typing the command line

```
tsh> /bin/ls -l -d
```

runs the `ls` program in the foreground. By convention, the shell ensures that when the program begins executing its main routine

```
int main(int argc, char *argv[])
```

the `argc` and `argv` arguments have the following values:

```
argc == 3,

argv[0] == ''/bin/ls'',

argv[1]== ''-l'',

argv[2]== ''-d''.
```

Alternatively, typing the command line

```
tsh> /bin/ls -l -d &
```

runs the `ls` program in the background.

The `tsh` Specification

Your `tsh` shell should have the following features:

The prompt should be the string "`tsh> `".

The command line typed by the user should consist of a `name` and zero or more arguments, all separated by one or more spaces. If `name` is a built-in command, then `tsh` should handle it immediately and wait for the next command line. Otherwise, `tsh` should assume that `name` is the path of an executable file, which it loads and runs in the context of an initial child process (In this context, the term *job* refers to this initial child process).

`tsh` need not support pipes (`|`) or I/O redirection (< and >).

Checking Your Work

We have provided some tools to help you check your work.

Reference solution. The Linux executable `tshref` is the reference solution for the shell. Run this program to resolve any questions you have about how your shell should behave. *Your shell should emit output that is identical to the reference solution* (except for PIDs, of course, which change from run to run).

Shell driver. The `sdriver.pl` program executes a shell as a child process, sends it commands and signals as directed by a *trace file*, and captures and displays the output from the shell.

Use the -h argument to find out the usage of `sdriver.pl`:

```
unix> ./sdriver.pl -h
Usage: sdriver.pl [-hv] -t <trace> -s <shellprog> -a <args>
Options:
  -h            Print this message
  -v            Be more verbose
  -t <trace>    Trace file
  -s <shell>    Shell program to test
  -a <args>     Shell arguments
  -g            Generate output for autograder
```

We have also provided 16 trace files (`trace 01-10 .txt`) that you will use in conjunction with the shell driver to test the correctness of your shell. The lower-numbered trace files do very simple tests, and the higher-numbered tests do more complicated tests.

You can run the shell driver on your shell using trace file `trace01.txt` (for instance) by typing:

```
unix> ./sdriver.pl -t trace01.txt -s ./tsh -a "-p"
```

(the `-a "-p"` argument tells your shell not to emit a prompt), or

```
unix> make test01
```

Similarly, to compare your result with the reference shell, you can run the trace driver on the reference shell by typing:

```
unix> ./sdriver.pl -t trace01.txt -s ./tshref -a "-p"
```

or

```
unix> make rtest01
```

For your reference, `tshref.out` gives the output of the reference solution on all races. This might be more convenient for you than manually running the shell driver on all trace files.

The neat thing about the trace files is that they generate the same output you would have gotten had you run your shell interactively (except for an initial comment that identifies the trace). For example:

```
bass> make test15
./sdriver.pl -t trace15.txt -s ./tsh -a "-p"
#
# trace15.txt - Putting it all together
#

tsh> ./bogus
./bogus: Command not found.
tsh> ./myspin 10
Job (9721) terminated by signal 2
tsh> ./myspin 3 &
[1] (9723) ./myspin 3 &
tsh> ./myspin 4 &
[2] (9725) ./myspin 4 &
tsh> jobs
[1] (9723) Running    ./myspin 3 &
[2] (9725) Running    ./myspin 4 &
tsh> fg %1
Job [1] (9723) stopped by signal 20
tsh> jobs
[1] (9723) Stopped    ./myspin 3 &
[2] (9725) Running    ./myspin 4 &
tsh> bg %3
%3: No such job
tsh> bg %1
[1] (9723) ./myspin 3 &
tsh> jobs
[1] (9723) Running    ./myspin 3 &
[2] (9725) Running    ./myspin 4 &
tsh> fg %1
tsh> quit
bass>
```

Hints

Use the trace files to guide the development of your shell. Starting with `trace01.txt`, make sure that your shell produces the *identical* output as the reference shell. Then move on to trace file `trace02.txt`, and so on.

Programs such as `more`, `less`, `vi`, and `emacs` do strange things with the terminal settings. Don't run these programs from your shell. Stick with simple text-based programs such as `/bin/ls`, `/bin/ps`, and `/bin/echo`.

Evaluation

Your score will be computed out of a maximum of 100 points based on the following distribution:

90 Correctness: 10 trace files at 9 points each.
10 Report : For each function, write 1 ~ 2 page (maximum 2 pages) report explaining each function in files.

Your solution shell will be tested for correctness on a Linux machine, using the same shell driver and trace files that were included in your lab directory. Your shell should produce **identical** output on these traces as the reference shell, with only two exceptions:

The PIDs can (and will) be different.

The output of the `/bin/ps` commands in `trace11.txt`, `trace12.txt`, and `trace13.txt` will be different from run to run. However, the running states of any `mysplit` processes in the output of the `/bin/ps` command should be identical.

Submit

Please upload your all files including tsh.c and report(.pdf) in your gitlab repository. We will check the time you submit and only consider the most recent code as well as report.