

OS Project1 Example

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1 Pipe Lab

1.1 Correct usage

As can be seen in Figure 1, the program copied the contents from "Src.txt" to "Dest.txt" correctly.

```
~/Desktop/courses/os/lab/project1/pipe_lab cat src.txt
2
8 5
5 9
8 5
5 9
8 5
5 9

~/Desktop/courses/os/lab/project1/pipe_lab ./Copy src.txt dest.txt 32
Finish read.
Finish write.
Elapsed time: 0.108000 ms

~/Desktop/courses/os/lab/project1/pipe_lab cat dest.txt
2
8 5
5 9
8 5
5 9
8 5
5 9
```

Figure 1: The result of program.

1.2 Error throwing

From Figure 2, we can find that the program printed error message and exited gracefully when the number of arguments is incorrect or the argument <BufferSize> is in different format.

```
~/Desktop/courses/os/lab/project1/pipe_lab ➤ ./Copy src.txt dest.txt
Wrong number of arguments!
Usage: ./Copy <InputFile> <OutputFile> <BufferSize>

~/Desktop/courses/os/lab/project1/pipe_lab ➤ ./Copy src.txt dest.txt size
Error occurred, buffer size must be a positive integer!

~/Desktop/courses/os/lab/project1/pipe_lab ➤ ./Copy src.txt dest.txt -1
Error occurred, buffer size must be a positive integer!
```

Figure 2: Error argument.

From Figure 3, the program also sends error message and exits when the input file doesn't exist.

```
~/Desktop/courses/os/lab/project1/pipe_lab ➤ ./Copy NotFound dest.txt 32
Error occurred during opening file!
```

Figure 3: File doesn't exist.

2 Shell Lab

2.1 Start-up and connect

From Figure 4 and 5, we can see that the server has successfully started and connected to a client.

```
~/De/co/o/l/p/shell_lab ➤ 111 !2 ?9 ➤ ./shell 4399
-----
Welcome to the shell
-----
Port number: 4399
Connection 0 established
█
```

Figure 4: Successful starting.

```
~/De/co/o/l/p/shell_lab ➤ 111 !2 ?9 ➤ telnet localhost 4399
Trying ::1...
Connection failed: 拒绝连接
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ █
```

Figure 5: Successful starting.

From Figure 6, server will print error message and exit when the number of arguments is incorrect or the format of port number is wrong or the user input a reserved port number.

```

~/Desktop/courses/os/lab/project1/shell_lab 111 !2 ?!0 > ./shell -1
Error: invalid port number
Usage: ./shell <port>

~/Desktop/courses/os/lab/project1/shell_lab 111 !2 ?!0 > ./shell
Error: invalid number of arguments
Usage: ./shell <port>

~/Desktop/courses/os/lab/project1/shell_lab 111 !2 ?!0 > ./shell asdasd asdasd
Error: invalid number of arguments
Usage: ./shell <port>

~/Desktop/courses/os/lab/project1/shell_lab 111 !2 ?!0 > ./shell 123 123
Error: invalid number of arguments
Usage: ./shell <port>

```

Figure 6: Error argument.

2.2 Command: pwd

Figure 7 show the output of command "pwd".

```

/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ pwd
/home/hoi/Desktop/courses/os/lab/project1/shell_lab

```

Figure 7: pwd

From Figure 8, error message of the command are displayed.

```

/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ pwd noArgPls
pwd: too many arguments

```

Figure 8: pwd error.

2.3 Command: ls

From figure 9, we can see the output of command "ls" and the effect of its parameter "-a" and "-l". It's colorful :D.

```

/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ ls
'shell_lab report.pdf' r cmake-build-debug CMakeLists.txt Makefile shell.c
example shell.o shell Box
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ ls -a
. .. .git 'shell_lab report.pdf' r .idea cmake-build-debug CMakeLists.txt
Makefile shell.c example shell.o shell Box
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ ls -l
drwxr-xr-x 1 hoi hoi 162 Thu Mar 23 19:36:18 2023 .git
-rw-r--r-- 1 hoi hoi 0 Wed Mar 22 14:47:28 2023 'shell_lab report.pdf'
-rw-r--r-- 1 hoi hoi 30 Wed Mar 22 18:47:50 2023 r
drwxr-xr-x 1 hoi hoi 228 Thu Mar 23 19:31:32 2023 .idea
drwxr-xr-x 1 hoi hoi 134 Wed Mar 22 20:30:38 2023 cmake-build-debug
-rw-r--r-- 1 hoi hoi 119 Wed Mar 22 18:47:28 2023 CMakeLists.txt
-rw-r--r-- 1 hoi hoi 156 Wed Mar 22 18:48:09 2023 Makefile
-rw-r--r-- 1 hoi hoi 22232 Thu Mar 23 19:33:57 2023 shell.c
drwxr-xr-x 1 hoi hoi 92 Thu Mar 23 19:35:35 2023 example
-rw-r--r-- 1 hoi hoi 36608 Thu Mar 23 19:34:01 2023 shell.o
-rwxr-xr-x 1 hoi hoi 38672 Thu Mar 23 19:34:01 2023 shell
drwxr-xr-x 1 hoi hoi 26 Thu Mar 23 19:36:22 2023 Box

```

Figure 9: ls <Param>

Also, we can input directory and the program will show the contents of it.

```
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ ls example
start_up.png  pwd.png  ls1.png  pwd_error.png
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ ls -a example
.  ..  start_up.png  pwd.png  ls1.png  pwd_error.png
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ ls -l example
drwxr-xr-x 1 hoi hoi 196   Thu Mar 23 19:03:39 2023 start_up.png
drwxr-xr-x 1 hoi hoi 196   Thu Mar 23 19:03:39 2023  pwd.png
drwxr-xr-x 1 hoi hoi 196   Thu Mar 23 19:03:39 2023  ls1.png
drwxr-xr-x 1 hoi hoi 196   Thu Mar 23 19:03:39 2023  pwd_error.png
```

Figure 10: ls <Param> <Directory>

Command will print error message when receives wrong parameter or the directory doesn't exist.

```
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ ls -t
ls: invalid option -- 't'
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ ls -l Box NotFound
Box:
drwxr-xr-x 1 hoi hoi 212   Thu Mar 23 20:59:30 2023 'A apple'
drwxr-xr-x 1 hoi hoi 212   Thu Mar 23 20:59:30 2023 'A pear'

NotFound:
ls: cannot access 'NotFound': No such file or directory
```

Figure 11: ls error

2.4 Command: cat

From Figure 12, we can see output of command "cat".

```

/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ cat r
#!/bin/zsh
make
./shell "$1"

/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ cat r Makefile
#!/bin/zsh
make
./shell "$1"

CC=gcc

CFLAGS=-c -Wall

all: shell

shell: shell.o
    $(CC) shell.o -o shell $(LIBS)

shell.o: shell.c
    $(CC) $(CFLAGS) -g shell.c

clean:
    rm -rf *.o shell

```

Figure 12: cat <File>

Command will print error message when the file doesn't exist.

```

/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ cat r NotFound
#!/bin/zsh
make
./shell "$1"

cat: cannot open file: NotFound

```

Figure 13: cat error

2.5 Command: wc

From Figure 14, we can see output of command "cat".

```

/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ wc shell.c
705    2205    22096 shell.c
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ wc shell.c Makefile
705    2205    22096 shell.c
14      28      156 Makefile
719    2233    22252 total

```

Figure 14: wc <File> ..

Command will print error message when the file doesn't exist.

```

/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ wc shell.c NotFound
705    2205    22096 shell.c
wc: cannot open file
705    2205    22096 total

```

Figure 15: wc error

2.6 Command: cd

"cd" command can change the current directory.

```
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ cd .  
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ cd ..  
/home/hoi/Desktop/courses/os/lab/project1$ cd ~  
/home/hoi$ cd Desktop/courses  
/home/hoi/Desktop/courses$
```

Figure 16: cd <path>

Command will print error message when the path doesn't exist or user input too many arguments.

```
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ cd NotFound  
cd: no such file or directory  
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ cd Dic1 Dic2  
cd: too many arguments
```

Figure 17: cd error

2.7 Command: exit

"exit" command will end the connection between server and client.

```
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ exit  
Connection closed by foreign host.
```

Figure 18: exit

Command will print error message when user input too many arguments.

```
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ exit Hi!  
exit: too many arguments
```

Figure 19: exit error

2.8 Pipe symbol

Pipe symbol will forward the output of last command as the input of next command. The program will trim the command automatically, so the users don't need to be too worried about the format of commands.

```
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ cat shell.c | wc  
705    2205    22096  
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ cat shell.c | wc|wc|wc|wc|wc  
1      4      21
```

Figure 20: Pipe symbol

Error messages will be printed when there is pipe symbol at the beginning or end of command or there's no command between two symbols.

```

/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ |
Error parsing: pipe at the beginning or end
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ |wc
Error parsing: pipe at the beginning or end
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ |cat shell.c|wc
Error parsing: pipe at the beginning or end
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ cat shell.c | wc|
Error parsing: pipe at the beginning or end
/home/hoi/Desktop/courses/os/lab/project1/shell_lab$ cat shell.c || wc
Error parsing: pipe with no command in between

```

Figure 21: Pipe symbol error

2.9 Multi-client

Server supports simultaneous connection of multiple clients. As shown in Figure 22.

```

~/De/co/o/l/p/shell_lab 111 !2 ?10 ./she
ll 3366
-----
Welcome to the shell
-----
Port number: 3366
Connection 0 established
Connection 1 established
Connection 2 established
[]

~/De/co/o/l/p/shell_lab 111 !2 ?10 telne
t localhost 3366
Trying ::1...
Connection failed: 拒绝连接
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
/home/hoi/Desktop/courses/os/lab/project1/she
ll_lab$ pwd
/home/hoi/Desktop/courses/os/lab/project1/she
ll_lab
/home/hoi/Desktop/courses/os/lab/project1/she
ll_lab$ []

~/De/co/o/l/p/shell_lab 111 !2 ?10 telne
t localhost 3366
Trying ::1...
Connection failed: 拒绝连接
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
/home/hoi/Desktop/courses/os/lab/project1/she
ll_lab$ cd
/home/hoi$ ls
Desktop Downloads Templates Public Docume
nts Music Pictures Videos 'Nutstore Files
' cv_debug.log
/home/hoi$ []

~/De/co/o/l/p/shell_lab 111 !2 ?10 telne
t localhost 3366
Trying ::1...
Connection failed: 拒绝连接
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
/home/hoi/Desktop/courses/os/lab/project1/she
ll_lab$ cat server.c | wc
2      6      43
/home/hoi/Desktop/courses/os/lab/project1/she
ll_lab$ []

```

Figure 22: Multi-client support

2.10 Graceful shutdown

After entering "q" in the terminal of server, it will run the shutdown procedure. Because the server will be blocked at accept(), so the procedure will start after another client try to connect. Then the server will wait for all connections closed and exit.

```
~/De/co/o/l/p/shell_lab 111 !2 ?10 ./she
ll 3366
-----
Welcome to the shell
-----
Port number: 3366
Connection 0 established
Connection 1 established
Connection 2 established
q
The server will be shutdown, waiting for all
clients exiting

~/De/co/o/l/p/shell_lab 111 !2 ?10

~/De/co/o/l/p/shell_lab 111 !2 ?10 telne
t localhost 3366
Trying ::1...
Connection failed: 拒绝连接
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
/home/hoi/Desktop/courses/os/lab/project1/she
ll_lab$ pwd
/home/hoi/Desktop/courses/os/lab/project1/she
ll_lab
/home/hoi/Desktop/courses/os/lab/project1/she
ll_lab$ exit
Connection closed by foreign host.

~/De/co/o/l/p/shell_lab 111 !2 ?10 telne
t localhost 3366
Trying ::1...
Connection failed: 拒绝连接
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
Connection closed by foreign host.

~/De/co/o/l/p/shell_lab 111 !2 ?10
```

Figure 23: Graceful shutdown

3 Matrix Lab

3.1 Single-thread program

Single-thread program will read matrices from "data.in" and output the multiplication result to file. "data.out".

```
~/Desktop/courses/os/lab/project1/matrix_lab master +1 !7 ?13 cat data.in
2
1 0
0 1
1 0
0 1

~/Desktop/courses/os/lab/project1/matrix_lab master +1 !7 ?13 ./single
Single thread algorithm1 time: 0.000001

~/Desktop/courses/os/lab/project1/matrix_lab master +1 !7 ?13 cat data.out
1 0
0 1
```

Figure 24: Single-thread program

Error messages will be printed when it reads wrong arguments or matrices.

```
~/Desktop/courses/os/lab/project1/matrix_lab master +1 !7 ?14 ./single NoArgPls
No arguments needed
Usage: ./single

~/Desktop/courses/os/lab/project1/matrix_lab master +1 !7 ?14 ./single
Error opening file
```

Figure 25: Single-thread program error


```

~/Desktop/courses/os/lab/project1/matrix_lab master +1 !7 ?14 cat data.in
1 0
0 1
1 0
0 1

~/Desktop/courses/os/lab/project1/matrix_lab master +1 !7 ?14 ./single
No size at the beginning of file

~/Desktop/courses/os/lab/project1/matrix_lab master +1 !7 ?14 cat data.in
2
1 0 1
0 1 0
1 0
0 1

~/Desktop/courses/os/lab/project1/matrix_lab master +1 !7 ?14 ./single
The matrix is not square

~/Desktop/courses/os/lab/project1/matrix_lab master +1 !7 ?14 cat data.in
2
1 0
0 1
1 0
0 1
1 0

~/Desktop/courses/os/lab/project1/matrix_lab master +1 !7 ?14 ./single
The matrix is not square

```

Figure 26: Single-thread program error

3.2 Multi-thread program

Multi-thread program will read matrices from "data.in" and output the multiplication result to file. "data.out" when the number of arguments is 1.

```

~/Desktop/courses/os/lab/project1/matrix_lab master +1 !7 ?14 cat data.in
2
1 0
0 1
1 0
0 1
1 0

~/Desktop/courses/os/lab/project1/matrix_lab master +1 !7 ?14 ./multi
multi-thread algorithm time: 0.000642

~/Desktop/courses/os/lab/project1/matrix_lab master +1 !7 ?14 cat data.out
1 0
0 1

```

Figure 27: Multi-thread program without argument

When the number of arguments is 2, the program will set `argv[1]` as the size of matrices, generates two matrices according to the size received. The matrices will be written to "random.in" and the result of multiplication will be written to "random.out".

```

~/Desktop/courses/os/lab/project1/matrix_lab > master +1 !7 ?14 > ./multi 4
multi-thread algorithm time: 0.001102

~/Desktop/courses/os/lab/project1/matrix_lab > master +1 !7 ?14 > cat random.in
4
5 9 7 0
6 2 7 3
0 7 2 0
9 9 7 5
5 0 0 7
5 2 0 4
6 8 9 9
8 7 5 6

~/Desktop/courses/os/lab/project1/matrix_lab > master +1 !7 ?14 > cat random.out
112 74 63 134
106 81 78 131
47 30 18 46
172 109 88 192

```

Figure 28: Multi-thread program with argument

Error messages will be printed when it reads wrong arguments or matrices.

```

~/Desktop/courses/os/lab/project1/matrix_lab > master +1 !7 ?14 > ./multi Error
The matrix size must be a positive integer

~/Desktop/courses/os/lab/project1/matrix_lab > master +1 !7 ?14 > ./multi -1
The matrix size must be a positive integer

~/Desktop/courses/os/lab/project1/matrix_lab > master +1 !7 ?14 > cat data.in
1 0
0 1
1 0
0 1

~/Desktop/courses/os/lab/project1/matrix_lab > master +1 !7 ?14 > ./multi
No size at the beginning of file

~/Desktop/courses/os/lab/project1/matrix_lab > master +1 !7 ?14 > cat data.in
2
1 0 1
0 1 0
1 0
0 1

~/Desktop/courses/os/lab/project1/matrix_lab > master +1 !7 ?14 > ./multi
The matrix is not square

~/Desktop/courses/os/lab/project1/matrix_lab > master +1 !7 ?14 > cat data.in
2
1 0
0 1
1 0
0 1
1 0

~/Desktop/courses/os/lab/project1/matrix_lab > master +1 !7 ?14 > ./multi
The matrix is not square

```

Figure 29: Multi-thread program error