

Project 1B

Encrypted Network Communication

INTRODUCTION:

In this project, you will build a multi-process telnet-like client and server. This project is a continuation of Project 1A. It can be broken up into two major steps:

- Passing input and output over a TCP socket
- Encrypting communication

RELATION TO READING AND LECTURES:

This lab will build on the process and exception discussions, but it is really about researching and exploiting APIs.

PROJECT OBJECTIVES:

- Demonstrate the ability to research new APIs and debug code that exploits them
- Demonstrate ability to do basic network communication
- Demonstrate ability to do basic encryption
- Develop multi-process debugging skills

DELIVERABLES:

A single tarball (`.tar.gz`) containing:

- C source modules that compile cleanly (with no errors or warnings). You will have (at least) two source files: `lab1b-client.c` and `lab1b-server.c`, which should compile to the executables `lab1b-client` and `lab1b-server`, respectively.
- a `Makefile` to build the program (compiling it with the `-Wall` and `-Wextra` options) and the tarball. It should have distinct targets for the client and server, but it should also have a default target that builds both. It should also have the (now) traditional `clean` and `dist` targets.
- a `my.key` file, containing the encryption key to be used in the second part of this project.
- a `README` file describing the contents of the tarball and anything interesting you would like to bring to our attention (e.g. research, limitations, features, testing methodology).

PROJECT DESCRIPTION:

Study the following man pages:

- `mbedtls(3)` ...a data encryption library (aka `libmbedtls`)
- `socket(7)` ...for creating communication endpoints (networking)

Passing input and output over a TCP socket

Using Project 1A's `--shell` option as a starting point, create a client program (`lab1b-client`) and a server program (`lab1b-server`), both of which support a mandatory `--port=port#` switch. (Note: you can remove the `--`

shell option)

Your overall program design will look like the diagram above. You will have a client process, a server process, and a shell process. The first two are connected via TCP connection, and the last two are connected via pipes.

The client program

- The client program will open a connection to a server (port specified with the mandatory **--port=** command line parameter) rather than sending it directly to a shell. The client should then send input from the keyboard to the socket (while echoing to the display), and input from the socket to the display.
- Maintain the same non-canonical (character at a time, no echo) terminal behavior you used in Project 1A.
- Include, in the client, a **--log=filename** option, which maintains a record of data sent over the socket (see below).
- If a **^D** is entered on the terminal, simply pass it through to the server like any other character.
- if a **^C** is entered on the terminal, simply pass it through to the server like any other character.
- In the second part of this project we will add an **--encrypt=filename** flag to the client.
- If the client encounters an unrecognized argument it should print an informative usage message (on stderr) and exit with a return code of 1. If any system call fails, it should print an informative error message (on stderr) and exit with a return code of 1.
- Before exiting, restore normal terminal modes.

For all of this testing, the client and server will be running on the same host (localhost), but if you would like to add a **--host=name** parameter you should be able to access a shell session from other computers.

The server program

- The server program will connect with the client, receive the client's commands and send them to the shell, and will "serve" the client the outputs of those commands.
- The server program will listen on a network socket (port specified with the mandatory **--port=** command line parameter).
- accept a connection when it is made
- once a connection is made, fork a child process, which will exec a shell to process commands received; the server process should communicate with the shell via pipes (as you did in Project 1A).
- redirect the shell process's stdin/stdout/stderr to the appropriate pipe ends (similar to what you did in Project 1A).
- input received through the network socket should be forwarded through the pipe to the shell. Because the server forks the shell (and knows its process ID), the processing of **^C** (turning it into a **SIGINT** to the shell) must be done in the server. Similarly, when the server encounters a **^D** it should close the write side of the pipe to the shell (as was done in project 1A).
- input received from the shell pipes (which receive both stdout and stderr from the shell) should be forwarded out to the network socket.
- If the server gets an EOF or **SIGPIPE** from the shell pipes (e.g., the shell exits), harvest the shell's completion status, log it to stderr (as you did in project 1A), and exit with a return code of 0.
- If the server gets an EOF or read error from the network connection, (e.g. the client exits), close the write pipe to the shell, await an EOF from the pipe from the shell, and harvest and report its termination status (as above).
- If the server encounters an unrecognized argument it should print an informative usage message (on stderr) and exit with return code of 1. If any system call fails, it should print an informative error message (on stderr) and exit with an return code of 1.
- In the second part of this project we will add a **--encrypt=filename** flag to the server.

To send commands to the shell, you will need to start both the client and the server. On the client side, the behavior should be very similar to that of Project 1A, in that you will see your commands echoed back to the

terminal as well as the output from the shell. Do not display anything (other than error messages) on the server side.

If you are not familiar with socket programming, you may find this [tutorial](#) to be useful.

Choose a random port number (greater than 1024) for your testing. Port numbers below 1024 are reserved. Be advised that listeners may remain active for several seconds after the server exits; This means that you may get occasional socket-in-use errors if you start the server before the old listener is taken down.

Because the server is started independently from the client, it will have its own stderr and stdout which go to the terminal session from which it was started. If you want to implement debug output from the server, you can send it to the server's stdout (file descriptor 1).

Shut-down Order

If the client initiates the closing of the socket, it may not receive the last output from the shell. To ensure that no output is lost, shut-downs should be initiated from the server side:

1. an *exit(1)* command is sent to the shell, or the server closes the write pipe to the shell.
2. the shell exits, causing the server to receive an EOF on the read pipe from the shell.
3. the server collects and reports the shell's termination status.
4. the server closes the network socket to the client, and exits.
5. the client continues to process output from the server until it receives an error on the network socket from the server.
6. the client restores terminal modes and exits.

After reporting the shell's termination status and closing the network socket, the server should exit. Otherwise it would tie up the socket and prevent testing new server versions. After your test is complete, the client, server, and shell should all be gone. There should be no remaining orphan processes.

The --log option

To ensure that encryption is being correctly done, we will ask you to add a `--log=filename` option to your client. If this option is specified, all data written to or read from the server should be logged to the specified file. Prefix each log entry with **SENT # bytes:** or **RECEIVED # bytes:** as appropriate. (Note the colon and space between the word **bytes** and the start of the data). Each of these lines should be followed by a newline character (even if the last character of the reported string was a newline).

Sample log format output:

```
SENT 35 bytes: sendingsendingsendingsendingsending
RECEIVED 18 bytes: receivingreceiving
```

Encrypted communication

- you may need to install the `libmbedtls-dev` package to get the encryption library and its documentation.
- add a `--encrypt=keyfile` command line option to your client and server which, if included, will turn on encryption (of all traffic in both directions) and provide the key.
- Choose an encryption algorithm from Linux `libmbedtls`. Then modify both the client and server applications to encrypt traffic before sending it over the network and decrypt it after receiving it.
- Do encryption based on a key, taken from the file whose name is specified with the `--encrypt=` option. Create a key file and include it with your submission. We will test your program with your key, and others we create.

- Using your key and encryption algorithm, run a session and use the **--log** option to verify that encryption and decryption are working properly. The **--log** option should record outgoing data post-encryption and incoming data pre-decryption.
- Do not include your **--log** files with your submission; we will generate our own from your program.

NOTE: these are block encryption algorithms that we want to apply to data streams. You probably want to select the "cfb" (8-bit Cypher-Feedback Mode). For stream encryption/decryption to work, each process will need to use a separate encryption session (a separate call to `mbedtls_module_open`) for input and output (two sessions per process). This is necessary because, in cypher feedback mode, the encryption or decryption of any character is affected by the characters that preceded it. If two different interspersed streams use the same encryption session, any difference in processing order will render decryption impossible.

NOTE: You must use the same key and initialization vector for both the client and the server. This means that you should set the initialization vector to constant values (rather than the random values you will find in many examples). We will talk about ways to securely negotiate such seeds when we get into secure communications (and SSL).

Summary of exit codes

0 ... normal execution, shutdown on ^D
 1 ... unrecognized argument or system call failure

SUBMISSION:

Your **README** file must include lines of the form:

NAME: *your name*
EMAIL: *your email*
ID: *your student ID*

And, if slip days are allowed on this project, and you want to use some, this too must be included in the **README** file:

SLIPDAYS: *#days*

If, for instance, you wanted to use two slip-days, you would add the following line:

SLIPDAYS: 2

Your name, student ID, and email address should also appear as comments at the top of your `Makefile` and each source file.

Your tarball should have a name of the form `1ab1b-studentID.tar.gz`. You can sanity check your submission with this [test script](#).

We will test it on a departmental Linux server. You would be well advised to test your submission on that platform before submitting it.

GRADING:

Points for this project will be awarded:

value feature

Packaging and build (15% total)

- 5% un-tars expected contents
- 5% clean build of correct programs w/default action (no warnings)
- 3% Makefile has working clean and dist targets
- 2% reasonableness of README contents

Communication (50% total)

- 5% input properly echos (character at a time) from client
- 10% client passes (character at a time) data between server and terminal (with proper CR->NL mapping)
- 10% server passes (character at a time) data between client and shell (with proper NL->CRLF mapping)
- 5% ^D from client closes connection, restores terminal modes, exits RC=0
- 5% ^C from client sends a SIGINT to shell
- 5% server properly logs shell termination status
- 5% --log= option properly reports sent data
- 5% --log option properly reports received data

Encryption (25% total)

- 5% --encrypt option obtains and uses key file for encrypted communication
- 5% data is encrypted before sending (tested with --log option)
- 5% data is decrypted after receiving (tested with --log option)
- 5% encrypted commands sent to shell are properly decrypted before execution
- 5% encrypted output sent by shell are properly decrypted before display

Code Review (10%)

- 10% correct library use