1 Introduction

The BSLE is intended for you to demonstrate your ability to build a program that follows a specification provided by a senior developer that meets an operational requirement.

1.1 Overview

You are tasked with creating a secure file transfer utility. It will consist of two components: client and server.

- Client: This component will be written in Python 3.8. It will be the primary user interface to the file server.
- Server: This component will be written in C. It will run as a service, interact with one to many clients via a wire protocol that will be specified below, and store files delivered and retrieved by clients.

1.2 Administrative

1.2.1 Time Considerations

- Candidates will be given 10 business days without interruptions to complete this exam.
- Unavoidable interruptions will be compensated at a rate of one and a half (1.5) times the duration of interruption up to one day.
    - Example 1: A mandatory training event lasting two hours will result in an additional three hours for the candidate.
    - Example 2: A training holiday will result in an additional day for the candidate.

1.2.2 Assistance

- Candidates may ask for clarification on the project specification from the exam proctor, the senior developers in their organization, and/or a designated basic developer *if no senior developers are available.*
- Any source code that a candidate does not write must be clearly documented in source code via comments clearly attributing the source. This should occur in very limited cases and should not be excessive. If panel members deem that source code was plagiarized, or that documented sources were excessive, they will make a recommendation as such to the Lead Developer for final arbitration.
- Senior developers may provide limited assistance identifying isolated problems a candidate gets stuck on. The definition of "limited" is a ballpark estimate of approximately 5-10 minutes to spot and troubleshoot.

1.2.3 Constraints

For this project everything must be original code with exception to the C and Python standard libraries and POSIX Thread library. No third party libraries can be used in the release binary. Third party unit-testing libraries are authorized for debug and test builds. The *make* and *cmake* utilities are authorized as well an any build system that your proctor authorizes given it is relevant to your organization's build process. The source code shall adhere to the style guides specified in this document.

1.2.4 Reporting Exam Issues

If you discover any issues with the examination please create a GitLab issues in your repo. Your exam proctor will resolve your questions in a timely manner. The CSD Talent Manager maintains an open door policy for issues you believe should not be addressed in a GitLab issue.

2 Project Environment

2.1 Directory Structure

Build the project using either CMake or creating and manually filling out a Makefile so that it compiles the code you place in the *src* directory and outputs a binary named *capstone* in a *bin* directory. The *src* directory is for source files and private header files. You can organize the *src* directory however you see fit. The Makefile must run by running *make* from the root directory of this project. *Do not assume the bin directory exists.*

```
/
├── bin
│   └── example_server
├── build
├── include
├── test
│   ├── server
│   └── client
└── src
```

Alternately you may use CMAKE to replace the provided Makefile, but you must document the change in your User Manual.

2.2 Operating System

Ubuntu 20.04 LTS

2.3 Recommended Tools

```
apt update -yq && apt install -y \
       clang-tidy \
       cmake \
       valgrind \
       gdb \
       strace \
       git \
       python3
```

2.4 Coding Standards

This project *shall* adhere to the following style guides. Failure to follow this style guide will be explained in detail in the grading rubric document.

Language	Style Guide
C	BARR-C
Python 3.8+	Google Style Guide

3 Evaluation Criteria

3.1 General Criteria

4.1.1 Grading Rubric If all implementation priorities are met then the project will be graded according to the provided rubric. You should manage your time to ensure you complete the implementation in accordance with the rubric.

3.1.2 Git Flow Your account will not have permission to merge to the master branch. A Merge Request to the merge the develop branch into master has been created for you. Only code in the develop branch will be graded via the existing Merge Request. It is encouraged to use the 'GitLab Flow' where your develop branch is treated like master in order to cleanly organize your exam, but the only requirement is that your submission is committed to develop.

3.2 Documentation

3.2.1 Comments Code is expected to be well documented. Comments should be succinct and meaningful - i.e. do not explain *what* the code is doing, but rather explain *why* you implemented it the way you did.

3.2.2 User Manual Candidate must provide a User Manual. It should be a detailed document containing instructions on how to compile and run the project. At a minimum it should include the following:

- Project compilation
- How to start the service
- How to connect
- How to interact with client
- Known issues

3.3 Programming

3.3.1 General Guidance

- Data validation and error checking must be performed where appropriate interfaces exist.
- Clear concise naming conventions used.
- Proper memory management

3.3.2 Server

- Must be written in C.
- Uses user-based permissions for server operations
    - READ: can get files from server
    - READ/WRITE: can get and put files from server
    - ADMIN: can get and put files from server and delete existing users
- Supports registering new users and deletion of existing users.
    - Users should only be able to create other users at their own permission level and below
- Support listening for multiple clients at a time.
- Ensure client operations are restricted to within a specified directory.
- Management of sessions (unique session IDs, enforcement of session timeout, etc)
- Must create a default user with admin permissions with username: “admin”, and password : “password” (for the purposes of the panel’s testing script)
- Server must accept the following settings as command line options
    - -t : timeout (in seconds) of user Session IDs
    - -d : folder to server; files/directories can be created inside of this directory, but not outside of it
    - -p : port server will listen on

3.3.3 Client

- Must be written in Python3
- Filenames containing "." and ".." (assuming the server is not in the top level directory) should function as they do in Linux.
- Connect to the server at a specified PORT and IP address (Both should be command line arguments)
- All functionality available through CLI arguments and an alternate fully interactive terminal.
- Support the following operations:

Command	Description
get [src] [dst]	Gets a file from server [src] path and copies it into the client [dst] path
put [src] [dst]	Sends a file from client [src] path to be placed in the server [dst] path
help [opt: command]	Print available commands, optionally describes given command
quit / exit	Closes client
delete [path]	Deletes file at server [path]
l_delete [path]	Deletes file at local [path]
ls [optional path]	Lists remote directory contents
l_ls [optional path]	Lists local directory contents
mkdir [path]	Makes directory at server [path]
l_mdkir [path]	Makes directory at client [path]

- The client must support user operations (create and delete user) in accordance with the wire protocol specified in section 4.1. It is up to your discretion how to implement the 'User Operation' commands on the client side, but you must document how it is to be used in your product User Manual.
- NOTE: All [path] values sent to server should be RELATIVE to the server home directory. Putting a file at path '/ ' should place that file in the server's home directory.

3.4 Presentation

Following completion of the project, the developer candidate must present and discuss the completed project with a panel of graders. The presentation will be an opportunity for the developer candidate to explain and defend the design and implementation of the project.

4 Detailed Capability Requirements

4.1 Wire Protocol and Sequence Diagrams

The message size used by both the client and server will limited to 2048 bytes, and the maximum file size that can be sent should be limited to 1016 bytes.

Any multi-byte integers described in the wire protocol MUST be transmitted in network byte order (big-endian).

Any field in the wire protocol that contains an ellipsis "..." indicates a variable length field. Anything that comes after it will be concatenated. Example: "Username... Password..." indicates that a username of "admin" and password "secret" should be written to the buffer in the format "adminsecret."

Client/Server operations and responses defined in the Wire Protocol are each associated with single byte op-code/return code. These are outlined in the tables below:

Operation Codes

User Operation	0x01
Delete remote file	0x02
List remote directory	0x03
Get remote file	0x04
Make remote directory	0x05
Put remote file	0x06

Return Codes

Code	Value	Description
Success	0x01	Server action was successful
Session error	0x02	Provided Session ID was invalid or expired
Permission error	0x03	User associated with provided Session ID had insufficient permissions to perform the action
User exists	0x04	User could not be created because it already exists
File exists	0x05	File could not be created because it already exists
Failure	0xff	Server action failed

User Operation

User Operation (Client Request)								
	0	1	2	3	4	5	6	7
+0	OPCODE	USER FLAG	RESERVED		USERNAME LENGTH		PASSWORD LENGTH	
+8	SESSION ID				USERNAME... + PASSWORD...			

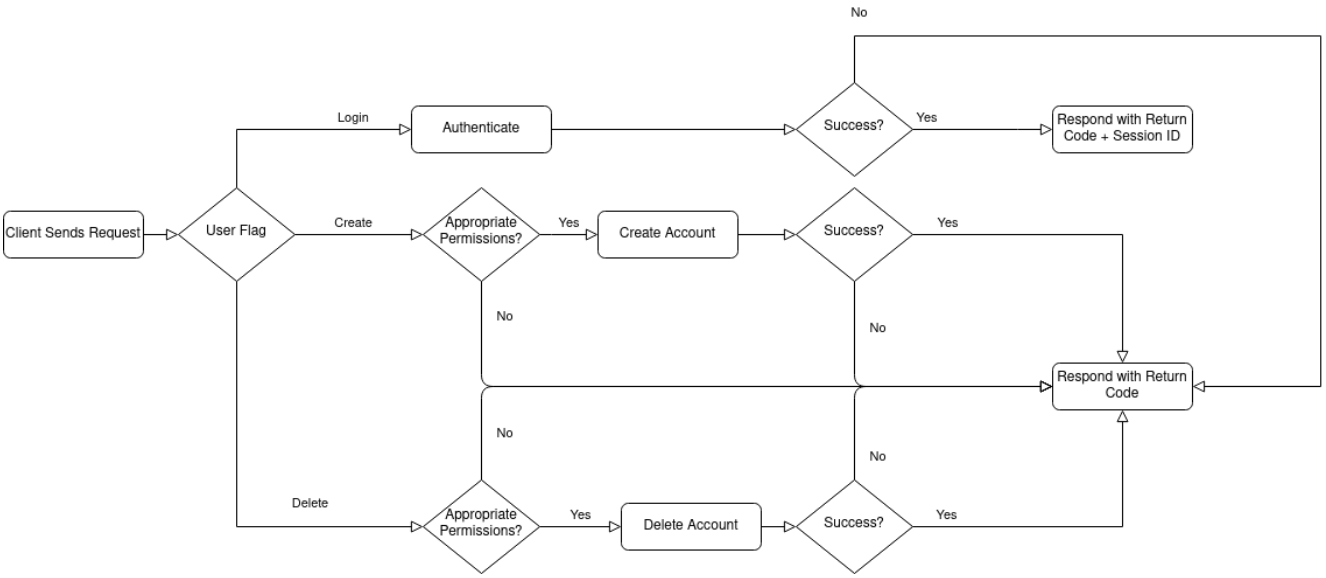
User Operation (Server Response)								
	0	1	2	3	4	5	6	7
+0	RETURN CODE	RESERVED	SESSION ID					

User Flag Codes		
Code	**Value**	**Description**
Login	0x00	A standard login message (No Session ID required)
Create Read Only	0x01	Create the given user with Read permissions (Valid Session ID required)
Create Read/Write	0x02	Create the given user with Read/Write permissions (Valid Session ID required)
Create Admin	0x03	Create the given user with Admin permissions (Valid Session ID required)
Delete	0xff	Delete the given user (Valid Session ID required)

1. Client will send the appropriate opcode, followed by a 1-byte User Flag Code to indicate the operation to be performed, a 2-byte unsigned integer to indicate username length, 2-byte unsigned integer to indicate password length, a valid Session ID (if the action is not "Login"), and then the username and password.

2. If the 'User Flag' is set to 0x00, the server will attempt to authenticate the user credentials and create or refresh a session for that user. The server will then attempt to authenticate the credentials, returning either SUCCESS or FAILURE. If the authentication was a SUCCESS, the server will also send back a 4-byte Session ID. This ID will be used to authenticate the user for all further messages. It will be up to the Server to decide how long the Session ID will be valid, and the Server will invalidate expired Session IDs.

3. If the 'User Flag' is NOT set to 0x00, the server will check the validity of the Session ID and permissions of the associated user against the permission level required by the action. If the Session ID is valid and the associated user has appropriate permissions to perform the action, the server will perform the action, and reply with a Success return code if successful. Otherwise, it will return the appropriate return code.



Delete Remote File

Delete Remote File (Client Request)								
	0	1	2	3	4	5	6	7
+0	OPCODE	RESERVED	FILENAME LENGTH		SESSION ID			
+8	FILENAME...							

Delete Remote File (Server Response)								
	0	1	2	3	4	5	6	7
+0	RETURN CODE							

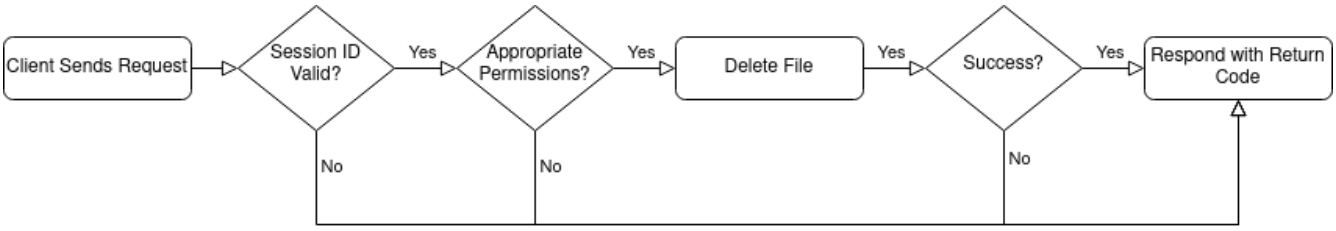
Client will send the appropriate OPCODE, the length of the filename as an 2-byte unsigned integer, and a valid Session ID, followed by the Filename to be deleted.
NOTE: Filenames should be the path relative to the server's home directory.

The server will check if the Session ID is valid, returning SESSION_ERROR if it is not.

If the session is valid, the Server will verify that the user associated with that Session ID has the appropriate permissions to delete files and return PERM_ERROR if not.

If the user has permission to delete files, the server will find the file indicated by the Filename, and attempt to delete it.

If the action is successful, the server will return SUCCESS. Otherwise, it will return FAILURE.



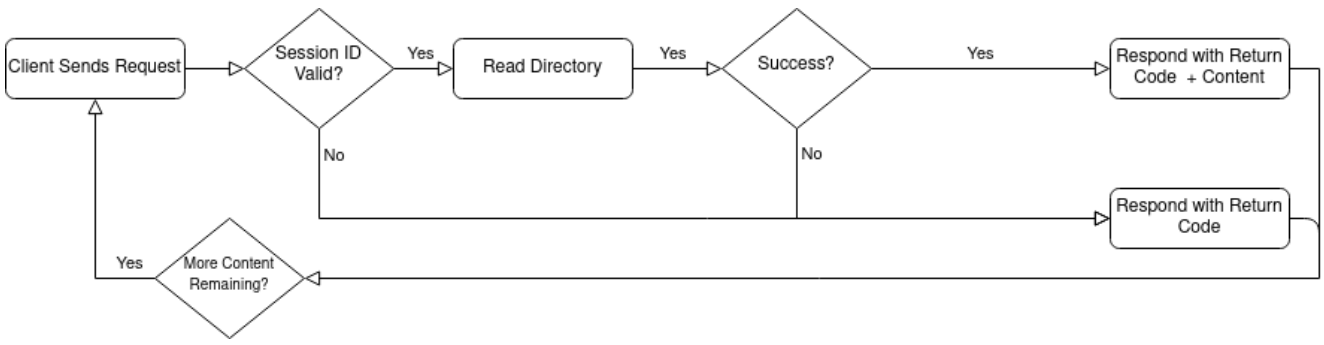
List Remote Directory

List Remote Directory (Client Request)								
	0	1	2	3	4	5	6	7
+0	OPCODE	RESERVED	DIRECTORY NAME LENGTH		SESSION ID			
+8	CURRENT POSITION (NUMBER OF BYTES ALREADY RECEIVED)				DIRECTORY NAME...			

List Remote Directory (Server Response)								
	0	1	2	3	4	5	6	7
+0	RETURN CODE	RESERVED			TOTAL CONTENT LENGTH (TOTAL NUMBER OF BYTES OF ALL CONTENT)			
+8	MESSAGE CONTENT LENGTH (NUMBER OF BYTES INCLUDED IN THIS MESSAGE)				CURRENT POSITION (POSITION WITHIN TOTAL CONTENT LENGTH MESSAGE ENDS AT)			

Server Response Content Format					
1-BYTE 0x01 (if file) 0x02 (if dir)	FILE/DIR NAME	NULL BYTE	1-BYTE 0x01 (if file) 0x02 (if dir)	FILE/DIR NAME	NULL BYTE

1. Client will send the appropriate OPCODE, a 2-byte unsigned integer of the length of the directory name, a valid Session ID, a 4-byte unsigned integer of the number of bytes already received (if it is a continuation), and the directory name.
   NOTE: Directory names should be the path relative to the server's home directory.
2. The server will validate the Session ID and respond with the return code, followed by the 4-byte unsigned integer total content length, a 4-byte unsigned integer indicating the number of bytes of content included in message, a 4-byte unsigned integer of the current position at the end of content length, and the content in the above Server Response Content Format
3. Repeat as necessary

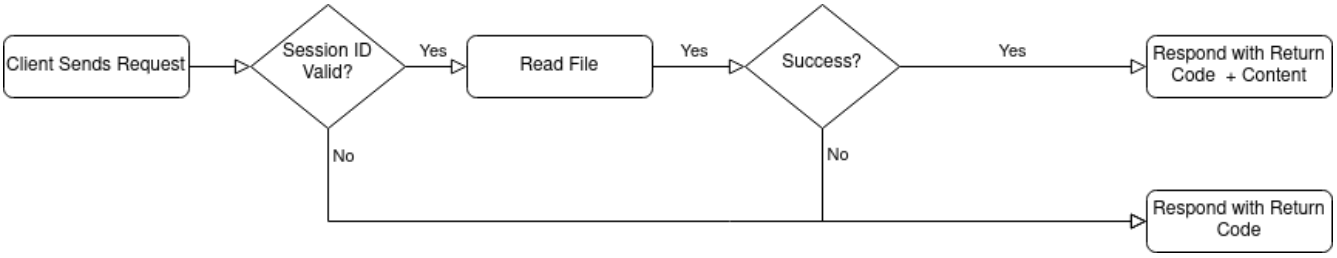


Get Remote File

Get Remote File (Client Request)								
	0	1	2	3	4	5	6	7
+0	OPCODE	RESERVED	FILENAME LENGTH		SESSION ID			
+8	FILENAME...							

Get Remote File (Server Response)								
	0	1	2	3	4	5	6	7
+0	RETURN CODE	RESERVED	CONTENT_LEN				CONTENT...	

1. Client will send the appropriate OPCODE, length of the file name as an 2-byte unsigned integer, and a valid Session ID, and the name of the file to be downloaded.
   NOTE: Filenames should be the path relative to the server's home directory.
2. The Server will respond (assuming no errors) with a SUCCESS, a 4-byte unsigned integer of the filesize in bytes, and then a buffer containing the file contents. If an error occurred, it will respond with the appropriate return code.

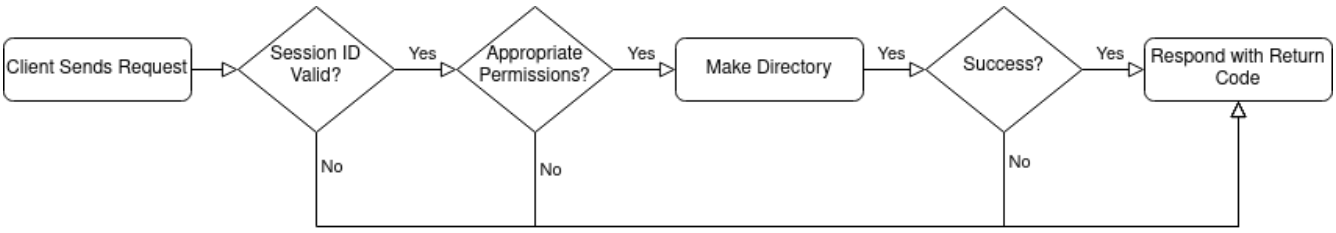


Make Remote Directory

Make Remote Directory (Client Request)								
	0	1	2	3	4	5	6	7
+0	OPCODE	RESERVED	DIRECTORY NAME LENGTH		SESSION ID			
+8	RESERVED				DIRECTORY NAME...			

Make Remote Directory (Server Response)								
	0	1	2	3	4	5	6	7
+0	RETURN CODE							

1. Client will send the appropriate OPCODE, length of the directory name as an 2-byte unsigned integer, and a valid Session ID, followed by the path of the directory to be created.
   NOTE: Directory names should be the path relative to the server's home directory.
2. The Server will validate the session ID and verify that the user associated with it has Read/Write or higher permissions, then create the directory respond (assuming no errors) with a SUCCESS. If an error occurred, respond appropriately.



Put Remote File

Put Remote File (Client Request)								
	0	1	2	3	4	5	6	7
+0	OPCODE	OVERWR-ITE FLAG	FILENAME LENGTH		SESSION ID			
+8	FILE CONTENT LENGTH				FILENAME... CONTENT...			

Put Remote File (Server Response)								
	0	1	2	3	4	5	6	7
+0	RETURN CODE							

Overwrite Flag Codes		
Code	**Value**	**Description**
No Overwrite	0x00	Do not overwrite existing file
Overwrite	0x01	Overwrite existing file

1. Client will send the appropriate OPCODE, 1-byte unsigned overwrite flag (set to overwrite if it desired to overwrite the file if it already exists), 2-byte unsigned integer representing the filename length, a valid Session ID, and the length of the file contents as an 4-byte unsigned integer, followed by the filename and contents of the file to be uploaded.
   NOTE: Filenames should be the path relative to the server's home directory.
2. The Server will validate the session ID and verify that the user associated with it has Read/Write or higher permissions, then create the directory respond (assuming no errors) with a SUCCESS. If an error occurred, respond appropriately. If the file trying to be uploaded already exists, and the Overwrite flag is not set, server will respond with FILE_EXISTS.