PROJECT AND TEAM INFORMATION

Project Title

Multithreaded Client-Server File Transfer

Student / Team Information

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PROPOSAL DESCRIPTION (10 pts)

Motivation (1 pt)

In today's world, the need for secure and reliable data transmission over networks is greater than ever. Whether it's transferring sensitive documents, backing up data, or syncing systems across multiple devices, **ensuring the integrity and completeness of files** during transmission is a critical challenge.
We chose this project to explore **real-time file transfer using multithreading over a network socket**, combined with **cryptographic integrity validation (SHA-256)**. By implementing client-server communication using TCP sockets and threading, we aimed to maximize performance and reliability. Furthermore, by incorporating **checksum-based validation**, we address an essential requirement in secure data transmission—**verifying that the file received is exactly the same as the one sent**.
This project not only deepened our understanding of **network programming, multithreading, file I/O**, and **cryptographic hashing**, but also reflects real-world applications in areas like software distribution, cloud storage services, and peer-to-peer systems. It represents a practical solution to a common problem, making it both technically enriching and highly relevant.

State of the Art / Current solution (1 pt)

Currently, there are numerous established solutions for file transfer and verification in both open-source and commercial domains. Tools like **rsync**, **scp**, **FTP**, and cloud-based services (e.g., Google Drive, Dropbox) handle file transmission over networks with varying levels of performance, encryption, and reliability.

These systems typically use **TCP/IP protocols** for reliable communication and may include integrity checks using **MD5**, **SHA-1**, or **SHA-256** hash algorithms to ensure that the file received matches the file sent. For example, **rsync** efficiently synchronizes files and supports checksum-based verification to detect corruption or mismatch during transfer.
On a lower level, file transfer protocols such as **HTTP**, **SFTP**, and **TFTP** provide mechanisms for segmented transmission, retries, and partial downloads, but are often implemented using large libraries or external dependencies.

While these tools are powerful, they are often black-box systems—offering limited customization or visibility into internal operations like threading behavior or segment handling. This project explores a more **lightweight, customizable approach**, where we implement multithreaded file transfer and SHA-256 checksum validation, giving us full control over how data is sent, received, and verified.

Project Goals and Milestones (2 pts)

Project Goals:

- Develop a **Client-Server architecture** using TCP sockets in C.
- Implement **multithreaded communication** for concurrent file segment transfer.
- Ensure **data integrity** using **SHA-256 checksum verification**.
- Allow the **client to reassemble** received segments into a complete file.
- Perform **checksum comparison** between client and server to confirm successful transfer.
- Use **mutex locks** to safely manage concurrent file writes during multi-threaded execution.

Project Milestones:

- Set up the **development environment** (GCC, OpenSSL, socket headers).
- Establish a **basic TCP socket connection** between client and server.
- Implement **multithreading** on both client and server sides.
- Perform **file I/O operations** for segment reading and writing.
- Integrate **SHA-256 checksum calculation** using OpenSSL EVP APIs.
- Use **mutex locking** to handle thread synchronization during file writing.
- Conduct **testing and debugging** with various file sizes and thread counts.

Project Approach (3 pts)

Client-Server Architecture

- Built using TCP sockets to enable reliable, connection-oriented communication between client and server.
- Server listens for incoming connections and handles requests for file transfers.

Multithreading for Efficiency

- The server uses multiple threads to divide the file into segments and send them concurrently.
- The client creates corresponding threads to receive and write segments to the output file simultaneously.
- Threads are managed using the pthread library for parallelism and performance.

File Segmentation and Transmission

- Files are read in chunks (e.g., 1024 bytes per segment) on the server side.
- Each segment is transmitted over the socket to the client thread responsible for writing it.

Data Synchronization with Mutex Locks

- A pthread_mutex_t lock ensures that file writes are not corrupted when multiple threads write to the same file.
- Only one thread writes at a time to prevent race conditions.

Checksum Generation and Verification

- Before sending the file, the server computes a **SHA-256** hash using the OpenSSL EVP interface and sends it to the client.
- After receiving and assembling the file, the client calculates its own SHA-256 hash.

- The two hashes are compared to validate the **integrity** of the transferred file.

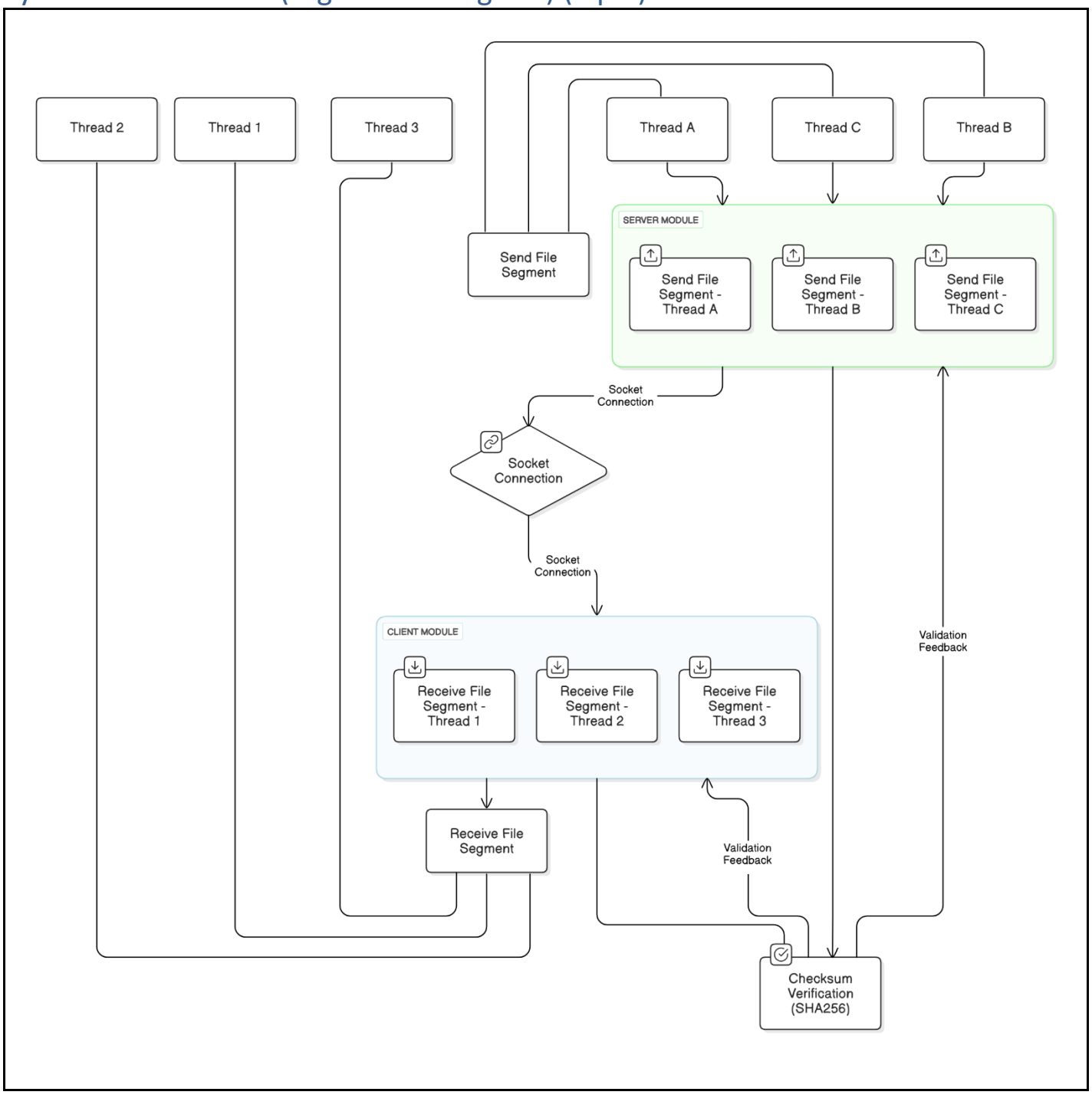
Error Handling and Debugging

- Includes checks for socket creation, connection failures, file I/O issues, and hashing errors.
- Debug messages (e.g., bytes received, hash comparison) are printed for clarity and troubleshooting.

Modularity and Reusability

- Functions are divided clearly: hashing, segment handling, thread management, and socket communication.
- The code is written to be extendable for future features such as encryption, file compression, or GUI support.

System Architecture (High Level Diagram) (2 pts)



Project Outcome / Deliverables (1 pts)

The deliverables include:

- A **working Client-Server application** built in C using TCP sockets for reliable file transfer.
- Implementation of **multithreaded data transmission** to handle file segments concurrently.
- Successful **file reassembly** on the client side from received segments.
- **SHA-256 checksum verification** to ensure end-to-end file integrity.
- Clear **console-based output logs** showing file transfer status and hash comparison results.
- A well-documented **C source codebase** with comments and modular functions.

Assumptions

- The client and server **run on the same local network** or localhost (127.0.0.1) for testing purposes.
- The **file to be transferred exists** on the server and has appropriate read permissions.
- The number of threads provided by the client is a **positive integer** and within practical system limits.
- The **network delay or latency is minimal**, allowing real-time communication between threads.
- Only **one client is connected to the server** at a time during file transfer.
- All required libraries (e.g., OpenSSL for hashing) are **properly installed** and linked.

References

- OpenSSL Project – Secure Sockets Layer toolkit
  https://github.com/openssl/openssl
- Stack Overflow: Alternatives to deprecated OpenSSL functions for SHA-256
  https://stackoverflow.com/questions/34289094/alternative-for-calculating-sha256-to-using-deprecated-openssl-code
- Deprecation of OpenSSL APIs
  https://docs.openssl.org/master/man3/SHA256_Init/
- Beej's Guide to Network Programming – Socket programming basics
  https://beej.us/guide/bgnet/
- Multithreading
  https://www.geeksforgeeks.org/multithreading-in-c/
- GeeksforGeeks – File handling and socket programming in C
  https://www.geeksforgeeks.org/socket-programming-cc/
  https://www.geeksforgeeks.org/file-handling-c-classes/