

CS 1653: Applied Cryptography and Network Security

Fall 2022

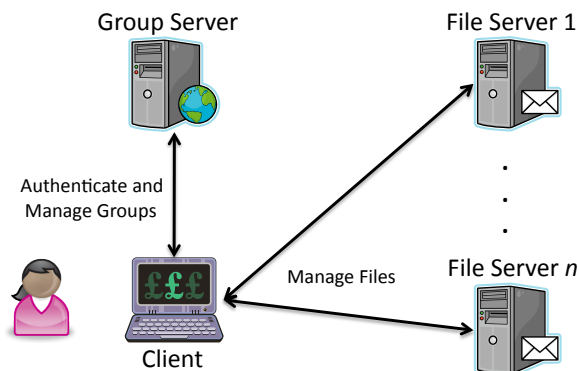
Term Project, Phase 2

Assigned: Wed, Sep 21

Due: Thu, Oct 06, 11:59 PM

1 Background

Over the course of this semester, we will experiment with and apply the security concepts that are covered in lecture by developing a group-based file sharing application that is secure against a number of different types of security threats. In this phase of the project, you will implement a bare-bones system that provides the necessary functionality *without* any security features. Recall that the system will consist of three main components: a single group server, a collection of file servers, and some number of clients.



The *group server* manages the users in the system and keeps track of the groups to which each user belongs. Any number of *file servers* can be deployed throughout the network, and will rely on the group server to provide each legitimate user with an authentication and authorization token that answers the question “*Who are you, and what are you permitted to do?*” Users within the system make use of a networked *client application* to log in to the system and manage their groups (via the group server), as well as upload, download, modify, and delete files stored in the system (via the file servers).

Your project submissions will be made using the git distributed version control system. You are encouraged to use this system to help coordinate your group work, and follow the git best practice: “commit early and often.”

2 Trust Model

In this phase of the project, you should focus on implementing the *core functionality* of the file sharing service, and will defer the implementation of *security features* to later phases of the project. The reason for this is twofold. From a pragmatic perspective, you have not yet learned all of the security “tricks and tools” that you will need to properly secure this type of application. Furthermore, having a fully-functional system in hand may simplify the later phases of the project, as you will only be debugging security features, not security features *and* core functionality. (Note that our high-level design already takes into account the security goals you will try to achieve later. Thus, this does not fall into the category of “retrofitting security as an afterthought” that we have discussed in lecture, at least not to the same degree.) When implementing this phase of the project, you may make the following assumptions about the participants in the system.

- **Group Server** The group server is entirely trustworthy. In this phase of the project, this means that the group server will always behave *exactly* as specified in its interface (see `GroupClientInterface.java` in provided code).
- **File Servers** The file servers are all entirely trusted. In this phase of the project, this means that each file server will behave *exactly* as specified in its interface (see `FileClientInterface.java` in provided code). For example, this means that you need not worry about a file server modifying a user’s token, making unauthorized use of a user’s token (e.g., using the token at another file server or disclosing the token to another client), or leaking the contents of a group’s files to non-members.
- **Clients** All clients will behave in a trustworthy manner. This means that clients will not share their tokens with one another, nor will they make any attempt to modify their tokens or login as other users.
- **Other Principals** You may assume that the only principals in the system are the group server, file servers, and a single client. In particular, this means that you do not need to worry about the threats of passive attackers stealing information that is transmitted between the client and servers, or active attackers altering the data that is transmitted between the client and servers.

In short, you may assume that your code will be run by trustworthy principals in a closed environment. This does not mean that you should ignore good error handling and input validation, but you can assume that all entities in the system are trusted not to be malicious.

3 What do I need to do?

In this phase of the project, you will be building two pairs of client/server applications: a group server and corresponding client application, and a file server and corresponding client application. If you have never written a client/server application in Java, you might want to check out the following repository, which contains a simple chat client/server application that could provide some helpful hints:

<https://github.com/2231-cs1653/server-sample>

Much of the code needed for this project is provided below. We now explain this code in detail.

3.1 The Group Server

The primary purpose of the group server is to manage user-to-group bindings. In particular, the group server is a central point at which (i) an administrator can create or delete users; (ii) any user can create groups, delete groups, and add other users to the groups that they create; and (iii) a user can obtain a *token* that can be used to prove that they are members of certain groups. Once a user obtains a token from the group server, they can log into one or more file servers to upload, download or delete files.

To implement the required functionality, you will need to develop a client application that implements all of the functionality described in `GroupClientInterface.java` from the included code. Most of the functionality enabling these client/server operations is encapsulated in `GroupClient.java`, `GroupServer.java`, and their associated classes. We now briefly describe the functionality that your group server and client need to implement.

- `boolean connect(String server, int port)`
Your implementation of this interface method is responsible for establishing a connection to the group server. No other method provided by your group client application should be able to work until this connection is established.
- `void disconnect()`
This method is responsible for cleanly tearing down the connection to the group server. It should be invoked when exiting the client application, or any other time that the user wishes to disconnect from a particular group server.
- `UserToken getToken(String username)`
This method is used to obtain the token describing the group memberships of a particular user. Given that we are working under a completely open trust model, the client does not need to “log in” to obtain this token: simply providing the user name is good enough for this phase of the project.
- `boolean createUser(String username, UserToken token)`
This method creates a new user at the group server. The `token` parameter is used to identify the user who is requesting the creation of the new account. This should only succeed if the requesting user is a member of the administrative group “ADMIN”. That is, not all users should be allowed to create other user accounts.
- `boolean deleteUser(String username, UserToken token)`
This method deletes a user account, and again, should only succeed when run by a user in the “ADMIN” group. Deleting a user account should also remove that user from all groups to which they belong.
- `boolean createGroup(String groupname, UserToken token)`
This method allows the owner of `token` to create a new group. The owner of `token` should be flagged as the owner of the new group. Any user can create a group.

- `boolean deleteGroup(String groupname, UserToken token)`
This method allows the owner of `token` to delete the specified group, provided that they are the owner of that group. After deleting a group, no user should be a member of that group.
- `boolean addUserToGroup(String user, String group, UserToken token)`
This method enables the owner of `token` to add the user `user` to the group `group`. This operation requires that the owner of `token` is also the owner of `group`.
- `boolean deleteUserFromGroup(String user, String group, UserToken token)`
This method enables the owner of `token` to remove the user `user` from the group `group`. This operation requires that the owner of `token` is also the owner of `group`.
- `List<String> listMembers(String group, UserToken token)`
Provided that the owner of `token` is also the owner of `group`, this method will return a list of all users that are currently members of `group`.

The `UserToken` interface plays an important role in most of the above methods, as it represents the binding between a user and the groups that he or she belongs to. Given the centrality of this interface, it would be prudent for your project group to design your implementation of this interface *before* tackling any other coding tasks.

3.2 The File Server

In our scenario, there will only be one group server, but there may be many file servers. After obtaining a token from the group server, a user can make use of *any* file server to manage his or her files. To implement the required functionality, you will need to develop a client application that implements all of the functionality described in `FileClientInterface.java`, which is largely encapsulated by `FileClient.java`, `FileServer.java`, and their associated classes. We now briefly describe the functionality that your file server client needs to implement.

- `boolean connect(String server, int port)`
Your implementation of this interface method is responsible for establishing a connection to the indicated file server. No other methods provided by your file client application should be able to work until this connection is established.
- `void disconnect()`
This method is responsible for cleanly tearing down the connection to the currently connected file server. It should be invoked when exiting the client application, or any other time that the user wishes to disconnect from a particular file server.
- `List<String> listFiles(UserToken token)`
This method generates a list of all files that can be accessed by members of the groups specified in `token`. The user should not be able to see any files that are shared with groups to which he or she does not belong.

- `boolean upload(String sourceFile, String destFile, String group, UserToken token)`

This method allows the owner of `token` to upload a file to be shared with members of `group`, provided that he or she is also a member of `group`. The `sourceFile` parameter points to a file on the local file system, while `destFile` is simply a name used to identify the file on the server.

- `boolean download(String sourceFile, String destFile, UserToken token)`

This method allows to owner of `token` to download the specified file, provided that he or she is a member of the group with which this file is shared.

- `boolean delete(String filename, UserToken token)`

This method allows the owner of `token` to delete the specified file on the server, provided that he or she is a member of the group with which this file is shared.

You *do not* need to implement support for traversing directories locally or remotely in this phase of the project. To simplify the coding tasks at hand, it is acceptable to assume that each file server exposes a single directory for users to upload to and download from.

3.3 Client Functionality versus Client Interfaces

After completing instances of the `GroupClientInterface` and `FileClientInterface` interfaces and the associated servers, your group must also develop a client application that allows a human user to access this functionality. Exactly what form the client application(s) take is entirely up to your group. For instance, one group might argue that a command-line application makes the most sense, as it can easily be run from within scripts without requiring a human to type commands or select menu options. Another group might argue that a text-based menu application makes the most sense, as you might *want* to require a human in the loop while still allowing the client application to be run via an SSH session. Finally, another group might argue that a user-friendly graphical application makes the most sense. However, you *must* implement at least one application that can be used from a terminal, so your demo can be completed from a terminal. Aside from this requirement, as long as your client application (or applications) provides a way for the user to execute all of the required client operations, it will be sufficient for this phase of the project.

Note that you **should not** hardcode specific server addresses or ports—in your demo your TA will specify the machines you should connect to. This means you should test your code multiple times using different machines playing the roles of the servers.

You are *strongly* encouraged to separate the application from your implementations of the `GroupClientInterface` and `FileClientInterface` interfaces. For instance, say that your group develops the `MyGroupClient` and `MyFileClient` classes that implement the above interfaces. You could then implement a class `MyClientApp` that provides the user-facing application. This clean separation provides you with several benefits. First, testing your client code is simplified, as the core functionality can be exercised in isolation. Second, your group can focus solely on implementing the client functionality before worrying about the client application. Lastly, you can implement more than one client application! For instance, you may develop a text-based client to begin with, but later decide to add GUI

functionality to simplify usage/testing in later phases of the project without reimplementing any of the client functionality beside the interface.

3.4 Development Tasks

The majority of the core functionality needed for developing (insecure) group servers, file servers, and clients is provided for you in your starter repository. Note that this repository will be used for **all future phases**.

Your job in this phase of the project is to complete the development of this system. In particular, you must do the following:

1. The code provided is nearly 2,000 lines of sparsely-commented Java code. Your first task should be to read and understand the interactions between *all* included components. Do not put off this task!
2. You will need to develop an implementation of the interface described in `UserToken.java`.
3. You will need to implement the `connect()` method in the `Client.java` class. If you are unfamiliar with client/server programming in Java, the following sample code may be helpful in this task:

`https://github.com/2231-cs1653/server-sample`

4. The file server implementation is nearly complete, but does not include the ability to list the files that a particular user is allowed to see. Edit the file server to include this functionality.
5. The group server implementation includes handlers for all user-related tasks (creation, deletion, etc.). However, the handlers needed to carry out group-related tasks are just stubs. You will need to complete the group server implementation to support all operations required by `GroupClientInterface.java`.
6. You will need to develop a client application capable of connecting to group and file servers. This application should allow the human user to carry out *all* functionality described in previous sections of this assignment. This application must be usable from a terminal (i.e., command-line or text-based application).

3.5 An Important Hint

Note that your implementation of the `UserToken` interface is the *only* connection between the group client/server and the file client/server. It is in the best interest of your group to write your implementation of the `UserToken` interface before undertaking any other coding tasks. Once you have done this, you can work on implementing the group client/server and the file client/server in parallel. This parallelization could save you a considerable amount of time!

4 Testing Environment

You will be asked to demonstrate your project's functionality using the last commit pushed to the default branch before the deadline, executing on the CS Linux Cluster. Your code will be evaluated based only on functionality that can be demonstrated on these machines with communications across the network. As such, you must test your code in this environment well before the deadline to identify any bugs that may not be apparent when running in other environments.

The addresses for these machines are:

- `ritchie.cs.pitt.edu`
- `kernighan.cs.pitt.edu`
- `thompson.cs.pitt.edu`

You can connect to these machines via SSH using your Pitt username and password.¹ In order to connect to these machines from off-campus, you will first need to connect to the Pitt VPN. Instructions for Pulse and GlobalProtect can be found on the Pitt IT page.

We recommend running the group server on one machine, the file server on another, and clients on a third. Note that home folders are automatically synchronized between these machines, which can mean files created by (e.g.) the group server can interfere with (or incorrectly pass information to) the file server. To be completely sure that communications are restricted to those implemented in your Java code, **each process should be run either by a different group member or from a different subfolder.**

5 Extra Credit

In this phase of the project, you have the opportunity to earn up to 8% extra credit. Should you happen to complete the required portions of the project early, consider adding in extra functionality in exchange for a few extra points (and a more interesting project). Any extra features that you add will qualify, but here are a few ideas to get you started:

- **Additional client applications** Although a text-based or command-line application to the group and file servers is required, adding a graphical application to your code would make it easier for you to test, and flashier to look at.
- **Support for the principle of least privilege** There may be times when a user does not want to have access to all of their groups at once. Adding support for the principle of least privilege (logging in with less than maximum allowed permissions) could be useful in these types of situations.

If you opt to do any extra credit, be sure to include a brief description of it when you submit the project (see Section 6). We will not give credit to extra features that are not explicitly described and identified as attempts at extra credit.

¹If you are running Windows, you may use the PuTTY SSH client. In the vast majority of cases, Mac, Linux, and other Unix-like operating systems will have command-line SSH clients pre-installed. Consult the documentation for your distribution if you need help.

6 What (and how) do I submit?

A repository will be created for your group via GitHub Classroom. You are encouraged to use this version control repository regularly while collaborating on this project, as each individual's contribution to the group's work will be judged in part by the version control logs.

Within your repository, include the following files and directories (this basic structure is already created for you—be sure to preserve it).

- **src/** In this directory, include all of your source code that is needed to compile your project. You may create subdirectories (packages) within this folder if you'd like to better organize the code. Please do not commit any JAR or class files, as we will be rebuilding your code before your demo (and it is common version-control etiquette not to commit files that can be re-derived from the included source). Also, please do not commit any publicly available libraries (e.g., Apache Commons) that you make use of—include instructions for acquiring those libraries in `doc/compile.txt` (see below).
Note that we will be grading your assignment using the CS Linux Cluster as stated in Section 4, so you must test your code in that environment prior to the submission deadline!
- **doc/** In this directory, include any documentation for your project, including *at least* the files named below.
- **desc/** In this directory, we provided this project description. No changes are necessary.
 - `doc/compile.txt` In this text file, please write detailed instructions for compiling your code, including direct links to any publicly available libraries that you used in your project. If you opt to use a Makefile or other script to build the code, include instructions here on how to run your build script.
 - `doc/usage.txt` In this text file, include explicit instructions on how to use your system. In particular, this should explain how to start your group server and file server, as well as how to start your client application(s). For each operation supported by your client application(s), provide a short statement of how to invoke this operation.
 - `doc/p1_extra_credit.txt` or `doc/p1_extra_credit.pdf` (*optional*) If you have gone beyond the requirements of the project as described in Section 5, please explain what you have done in this text file or PDF (no other formats accepted).

As mentioned above, your repository's commit log will serve (in part) to ensure each individual is contributing to the group project. In addition, *each student in your group* should send an email to `bill@cs.pitt.edu` that indicates their assessment of each group member's contribution to this phase of the project (e.g., *Bob did 40% of the work, and Mary did 60% of the work*).

Your project is due at the precise date and time stated above. We will clone your repository immediately after the due date, so you will be graded on whatever changes have

been committed **and pushed** to your repository's default branch by this time. No changes made after this point will be considered in your demo or in grading your project. Make sure your repository is created and you understanding the submission process well in advance!