EE450 Socket Programming Project

Spring 2020

Due Date:

Friday, April 24, 2020 11:59PM

(Hard Deadline, Strictly Enforced)

The deadline is for both on-campus and DEN off-campus students.

ACADEMIC INTEGRITY

All students are expected to write all their code on their own.

Copying code from friends is called **plagiarism** not **collaboration** and will result in an "F" for the entire course. Any libraries or pieces of code that you use and you did not write must be listed in your README file. All programs will be compared with automated tools to detect similarities; examples of code copying will get an "F" for the course.

IF YOU HAVE ANY QUESTIONS ABOUT WHAT IS OR ISN'T ALLOWED ABOUT PLAGIARISM, TALK TO THE TA. "I didn't know" is not an excuse.

OBJECTIVE

The objective of this assignment is to familiarize you with UNIX socket programming. This assignment is worth **15%** of your overall grade in this course. **It is an individual assignment and no collaborations are allowed. Any cheating will result in an automatic F in the course (not just in the assignment).**

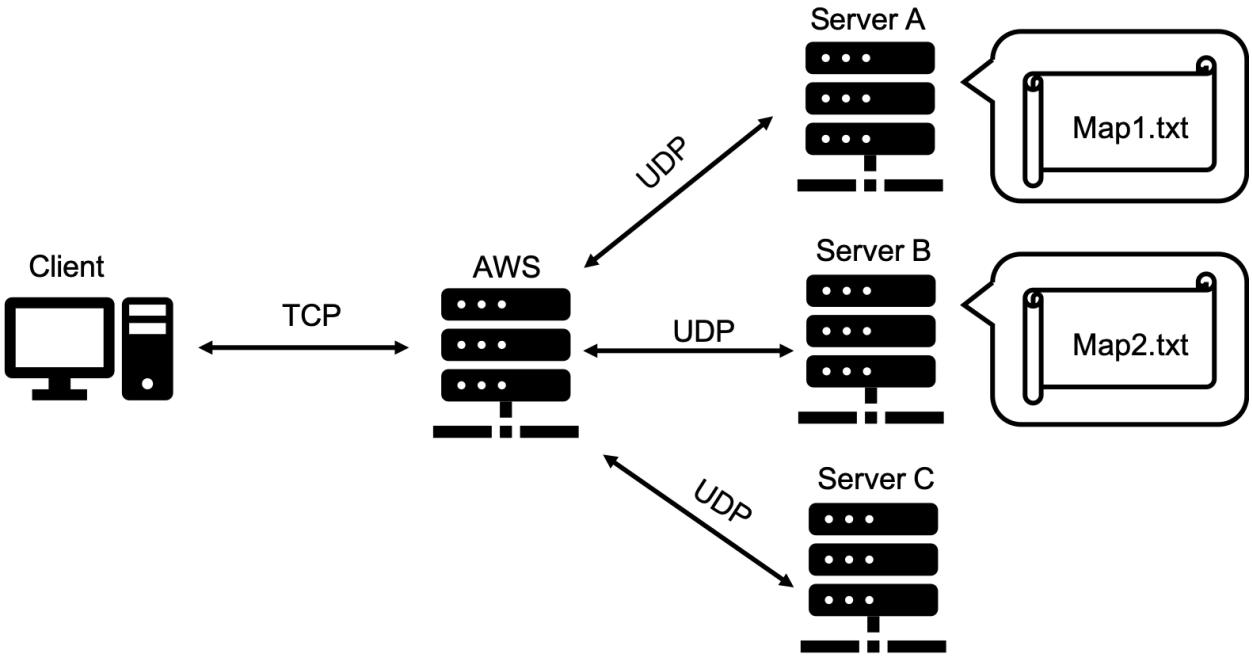
If you have any doubts/questions, post your questions on Piazza. **You must discuss all project related issues on Piazza**. We will give those who actively help others out by answering questions on Piazza up to 10 bonus points to the project.

You can ask TAs any question about the content of the project but TAs have the right to reject your request for debugging.

PROBLEM STATEMENT

Many network related applications require fast identification of the shortest path between a pair of nodes to optimize routing performance. Given a weighted graph $G(V, E)$ consisting of a set of vertices V and a set of edges E, we aim at finding the path in G connecting the source vertex v_1 and the destination vertex v_n, such that the total edge weight along the path is minimized. Dijkstra Algorithm is a procedure of finding the shortest path between a source and destination nodes. This algorithm will be discussed later in the semester.

In this project, you will implement a distributed system to compute the shortest path based on client's query. Suppose the system stores maps of a city, and the client would like to obtain the shortest path and the corresponding transmission delay between two points in the city. The figure below summarizes the system architecture. The distributed system consists of three computation nodes: a main server (AWS), connected to three backend servers (Server A, Server B and Server C). The backend server A and B has access to a file named map1.txt and map2.txt, respectively, storing the map information of the city. For simplicity, there is no overlap of map ID between map1.txt and map2.txt. The AWS server interfaces with the client to receive his query and to return the computed answer. Upon the request from the client, the AWS server will initiate the search work in backend Server A and Server B. After searching, AWS server will send the map result to Server C to calculate the shortest path and different types of delays(propagation delay, transmission delay and total delay). After calculation, server C will send back the result to AWS. Then AWS will get it back to the client. If there is no matched map ID, AWS will send corresponding messages to the client.



Detailed computation and communication steps performed by the system is listed below:

1. [Communication] Client -> AWS: client sends the map ID, the source node and destination node in the map and the transmission file size (unit: KB) to AWS via TCP.

2. [Communication] AWS -> Server A: AWS forwards the map ID to server A via UDP.
3. [Search] Server A searches for the map ID from map1.txt.
4. [Communication] Server A -> AWS: Server A sends the search result via UDP.
5. [Communication] AWS -> Server B: AWS forwards the map ID to server B via UDP.
6. [Search] ServerB searches for the map ID from map2.txt.
7. [Communication] Server B -> AWS: Server B sends the search result via UDP.
8. [Communication] AWS -> ServerC: AWS sends the map information to server C via UDP.
9. [Calculation] Server C calculates the shortest path using Dijkstra Algorithm and propagation/transmission/total delay.
10. [Communication] Server C -> AWS: Server C sends the shortest path and delay values to AWS via UDP.
11. [Communication] AWS -> client: AWS sends to client the shortest path and delay results, and client prints the final results.

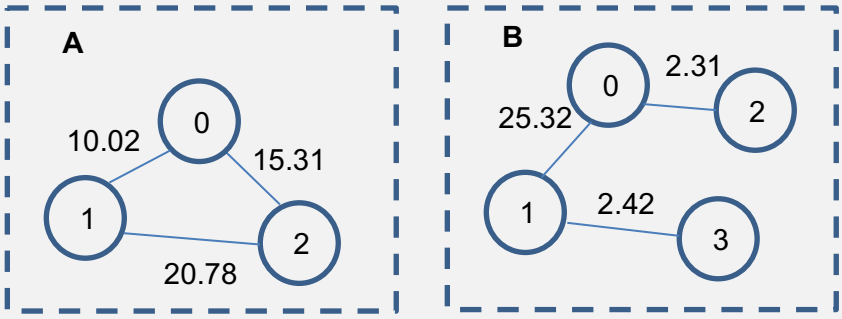
The map information of the city is stored in a file named map1.txt and map2.txt. The map1.txt and map2.txt files contain information of multiple maps (i.e. graphs), where each map can be considered as a community of the city. Within each map, the edge and vertex information are further specified, where an edge represents a communication link. We assume edges belonging to the same map have identical propagation speed and transmission speed.

The format of map1.txt or map2.txt is defined as follows:

```
<Map ID 1>
<Propagation speed>
<Transmission speed>
<Vertex index for one end of the edge> <Vertex index for the
other end> <Distance between the two vertices>
… (Specification for other edges)
<Map ID 2>
…
```

Example:

```
A
200000.00
8000000
0 1 10.02
0 2 15.31
1 2 20.78
B
150000.00
9089
0 1 25.32
0 2 2.31
1 3 2.42
…
```



Note:

1. For each map, the maximum number of vertices is 10
2. Vertices index is between 0 and 99
3. The maximum number of edges is 40
4. The graph is connected
5. We consider undirected, simple graphs:
   a. There are no repeated edges or self-loops
   b. An edge (p,q) in the graph means p and q are mutual neighbors
6. Datatype, Units, range:
   a. Propagation speed: float, km/s, [10000.00,299792.00)
   b. Transmission speed: int, KB/s, [1,1048576)
   c. Distance: float, km, [1.00,10000.00)
   d. Filesize: int, KB, [1,1048576)

We provide a sample map1.txt and map2.txt for you as a reference. To download the sample maps, please refer to the **DOWNLOAD SAMPLE MAPS** Section. We will use another map.txt for grading, so you are advised to prepare your own map files for testing purposes.

Source Code Files

Your implementation should include the source code files described below, for each component of the system.

1. AWS: The server can be viewed as a much simplified Amazon Web Service server. You must name your code file: **aws.c** or **aws.cc** or **aws.cpp** (all small letters). Also you must name the corresponding header file (if you have one; it is not mandatory) **aws.h** (all small letters).

2. Backend-Server A, B and C: You must use one of these names for this piece of code: **server#.c**

or **server#.cc** or **server#.cpp** (all small letters except for #). Also you must name the corresponding header file (if you have one; it is not mandatory) **server#.h** (all small letters, except for #). The "#" character must be replaced by the server identifier (i.e. A or B or C).

3. Client: The name for this piece of code must be **client.c** or **client.cc** or **client.cpp** (all small letters) and the header file (if you have one; it is not mandatory) must be called **client.h** (all small letters).

Note: Your compilation should generate separate executable files for each of the components listed above.

DETAILED EXPLANATION

Phase 1 (10 points)

All three server programs (AWS, Back-end Server A & B & C) boot up in this phase. While booting up, the servers must display a boot up message on the terminal. The format of the boot up message for each server is given in the onscreen message tables at the end of the document. As the boot up message indicates, each server must listen on the appropriate port for incoming packets/connections.

Once the server programs have booted up, the client program runs. The client displays a boot up message as indicated in the onscreen messages table. Note that the client code takes input arguments from the command line. The format for running the client code is:

```
./client <Map ID> <Source Vertex Index> <Destination Vertex Index> <File Size>
```

(Between two input arguments, there should be a space)

For example, if the client wants to calculate the end to end delay of each shortest path from source vertex 1 to vertex 3 in Map A, with file size of 1024 KB, then the command should be:

```
./client A 1 3 1024
```

After booting up, the client establishes TCP connections with AWS. After successfully establishing the connection, the client sends the input (map ID, source vertex index, destination vertex index and file size) to AWS. Once this is sent, the client should print a message in a specific format. This ends Phase 1 and we now proceed to Phase 2.

Phase 2 (80 points)

In the previous phase, the client receives the query parameters from the user and sends them to the AWS server over TCP socket connection. In phase 2, the AWS server will have to query server A and server B for the corresponding map, and forward the map data to server C for calculation if the map ID and vertex ID has been found.

The socket connection between AWS and server A, B, and C are established over UDP. Each of these servers and the AWS have its unique port number specified in Port Number Allocation section with the source and destination IP address as localhost/127.0.0.1/::1.

AWS, server A, B, and C are required to print out on screen messages after executing each action as described in the "On Screen Messages" section. These messages will help with grading in the event that the process did not execute successfully. Missing some of the on screen messages might result in misinterpretation that your process failed to complete. Please follow the exact format when printing the on screen messages.

Phase 2 can be subdivided into 2 phases. Phase 2A executes map storage while 2B will take the results from phase 2A and calculate the shortest path, transmission, and propagation delays if the map exists. Table 1 describes the implementation in detail.

Table 1. Server Operations	
Map Storage and Search	In this operation, you will read the data file (map1.txt and map2.txt) to their respective servers (serverA and serverB). The server will be ready for query look up from AWS and return the map data if found. AWS will send the map data only if the map ID and vertex ID exists.
Path Finding and Calculation	In this operation, you will find the path of minimum length from a given start vertex to all other vertices in the selected map, using Dijkstra algorithm, then compute the transmission delay (in s), the propagation delay (in s), and the end-to-end delay (in s) for transmitting a file of given size in the selected map.

You are not required to have exact named functions (map construction, path finding and calculation) in your code. These operations are named and divided to make the process clear.

Phase 2A (40 points)

Phase 2A starts when server A and server B boots up, each server will execute map lookup against its own database. Server A will read map1.txt while server B will read map2.txt. These servers will store the map data in a data structure and will send it to AWS if the queried map ID is found on its server. If the map ID or vertex ID is not found, the server simply notifies AWS and returns

to standby.

Server A reads and stores all maps from map1.txt only while serverB reads and stores all maps from map2.txt only. The queried map ID might not exist in both servers, or might exist in only one of the servers, but not both. Refer to the "Download Sample Maps" section to obtain the map1.txt / map2.txt files.

Phase 2B (40 points)

Phase 2B starts when AWS has received all required data from the client and the servers A,B. Depending on the lookup result of servers A and B, AWS will perform one of the two operations.

1. If the queried map ID exists in neither A nor B: in this case, server C has nothing to compute for the shortest path and delay. AWS will print out a message (see the "On Screen Messages" section) and will not have any interaction with server C.
2. If the queried map ID exists in one of servers, A or B: AWS will forward to server C: 1). the graph information received from A or B, and 2). the source and destination vertex indices and file size received from the client. After server C receives the information from AWS, it computes the shortest path and delay (from the source to the destination vertex) using Dijkstra's algorithm (i.e., the "Path finding and calculation" operation in Table 1). Upon completing the computation, server C will print out the calculation results (see the "On Screen Messages" section). Finally, server C will send the results to AWS, and AWS will print out the received data (see the "On Screen Messages" section). This concludes all the operations of Phase 2B.

Note:

You should decide on your own what information is required to be sent from AWS to server C. Similarly, it is your own choice what format / data structure to encode the AWS-to-server C and server C-to-AWS communication. We will grade based on your print out message only.

The goal of server C is to find the path from source to destination with shortest overall delay ($T_{trans}+T_{prop}$). Since for a given graph, all the links within it have the same transmission rate and we do not use store and forward transmission, the source-to-destination transmission delay, $T_{trans} = File\ size/transmission\ rate$, is fixed regardless of the route we choose. Therefore, the path with shortest overall delay is the same as the path with the shortest distance.

If the client's query is valid, both server C and AWS should print out the calculation result so that we can give you partial credit if the server C-to-AWS or AWS-to-client communication fail. The on-screen message should indicate the vertex indices along the path, the total distance of the shortest path and the delays. Please format your output so the table is clear and readable.

Phase 3 (10 points)

At the end of Phase 2B, backend server C should have the calculation results ready. Those results should be sent back to AWS using UDP. When the AWS receives the calculation results, it needs to forward all the results to the client using TCP. The results should include minimum path length

between the source and destination node and 3 delays to transfer the file to corresponding destination. The clients will print out a path and a table to display the response. The table should include 6 columns. One for source node index, one for destination node index, one for path length and the other three for delays.

Make sure you round the results of three delay time to the 2nd decimal point for display. Round the result **after** summing T_{trans} and T_{prop} along a path. Do not sum rounded T_{trans} and rounded T_{prop} as your total delay.

See the ON SCREEN MESSAGES table for an example output table.

DOWNLOAD SAMPLE MAPS

Samples of map1.txt and map2.txt for this project are available online for download. The data in these map.txt files are generated randomly for each download and vary in size, but the structure and data type of the map.txt files are consistent. map1.txt and map2.txt are expected to be read and stored into serverA and serverB respectively.

Download a copy of map.txt files here:

http://ee450project.us-west-1.elasticbeanstalk.com/

map1.txt and map2.txt will be archived into a single maps.zip for download. Unzip and put the files in your program directory before using it.

There are no download limits, but both map1.txt and map2.txt should be used together. Do not mix map1.txt and map2.txt from different maps.zip downloads!

Similar map.txt files with different contents will be used for grading, but you are expected to read these files without errors.

PORT NUMBER ALLOCATION

The ports to be used by the client and the servers are specified in the following table:

Table 2. Static and Dynamic assignments for TCP and UDP ports		
Process	**Dynamic Ports**	**Static Ports**
Backend-Server (A)	-	1 UDP, 30xxx
Backend-Server (B)	-	1 UDP, 31xxx
Backend-Server (C)	-	UDP, 32xxx
AWS	-	1 UDP, 33xxx 1 TCP with client, 34xxx
Client	1 TCP	-

NOTE: xxx is the last 3 digits of your USC ID. For example, if the last 3 digits of your USC ID are "319", you should use the port: **30319** for the Backend-Server (A), etc.

Port number of all processes print port number of their own

ON SCREEN MESSAGES

Table 3. Backend-Server A on screen messages	
Event	**On Screen Message**
Booting up (Only while starting):	The Server A is up and running using UDP on port <server A port number>
For graph finding, upon receiving the input query:	The Server A has received input for finding graph of map <ID>
For graph finding, no graph found	The Server A does not have the required graph id <graph id>
For graph finding, no graph found after sending to AWS:	The Server A has sent "Graph not Found" to AWS
For graph finding, after sending to AWS:	The Server A has sent Graph to AWS

Table 4. Backend-Server B on screen messages	
Event	**On Screen Message**
Booting up (Only while starting):	The Server B is up and running using UDP on port <server B port number>
For graph finding, upon receiving the input query:	The Server B has received input for finding graph of map <ID>
For graph finding, no graph found	The Server B does not have the required graph id <graph id>
For graph finding, no graph found after sending to AWS:	The Server B has sent "Graph not Found" to AWS
For graph finding, after sending to AWS:	The Server B has sent Graph to AWS

Table 5. Backend-Server C on screen messages	
Event	**On Screen Message**
Booting up (Only while starting):	The Server C is up and running using UDP on port <server C port number>
For calculation, after receiving data from AWS:	The Server C has received data for calculation: * Propagation speed: <speed1> km/s; * Transmission speed <speed2> KB/s; * map ID: <ID>; * Source ID: <ID> Destination ID: <ID>;
After calculation:	The Server C has finished the calculation: Shortest path: <src> -- <hop1> -- <hop2> … -- <dest> Shortest distance: <dist> km Transmission delay: <delay1> s Propagation delay: <delay2> s
Sending the results to the AWS server:	The Server C has finished sending the output to AWS

Table 6. AWS on screen messages	
Event	**On Screen Message**
Booting up (only while starting):	The AWS is up and running.
Upon Receiving the input from the client:	The AWS has received map ID <map ID>, start vertex <vertex ID>, destination vertex <vertex ID> and file size <file size> from the client using TCP over port <AWS TCP port number>
After sending information to server A	The AWS has sent map ID to server A using UDP over port <AWS UDP port number>
After sending information to server B	The AWS has sent map ID to server B using UDP over port <AWS UDP port number>
After receiving results from server A or B	The AWS has received map information from server <A/B>
Check nodes in graph: src and dst in graph	The source and destination vertex are in the graph
Check node in graph: vertex not in graph	<Source/destination> vertex not found in the graph, sending error to client using TCP over port <AWS TCP port number>
After sending information to server C	The AWS has sent map, source ID, destination ID, propagation speed and transmission speed to server C using UDP over port <AWS UDP port number>
After receiving results from server C	The AWS has received results from server C: Shortest path: <src> -- <hop1> -- <hop2> … -- <dest> Shortest distance: <dist> km Transmission delay: <delay1> s Propagation delay: <delay2> s
After sending results to client	The AWS has sent calculated results to client using TCP over port <AWS TCP port number>

Table 7. Client on screen messages	
Event	**On Screen Message**
Booting Up:	The client is up and running
After sending query to AWS	The client has sent query to AWS using TCP: start vertex <vertex index>; destination vertex <vertex index>, map <map ID>; file size <file size>
After receiving output from AWS	The client has received results from AWS: ---------- Source Destination Min Length Tt Tp Delay ---------- 0 1 0.10 0.10 0.10 0.20 ---------- Shortest path: <src> -- <hop1> -- <hop2> … -- <dest>
After receiving output AWS, errors	No map id <mad id> found or No vertex id <vertex index> found

ASSUMPTIONS

1. You have to start the processes in this order: **backend-server (A), backend-server (B), backend-server (C), AWS, and Client.**

2. The map1.txt and map2.txt files are created before your program starts.

3. If you need to have more code files than the ones that are mentioned here, please use meaningful names and all small letters and mention them all in your README file.

4. You are allowed to use code snippets from Beej's socket programming tutorial (Beej's guide to network programming) in your project. However, you need to mark the copied part in your code.

5. When you run your code, if you get the message "port already in use" or "address already in use", **please first check to see if you have a zombie process** (see following). If you do not have such zombie processes or if you still get this message after terminating all zombie processes, try changing the static UDP or TCP port number corresponding to this error message (all port numbers below 1024 are reserved and must not be used). If you have to change the port number, please do mention it in your README file and provide reasons for it.

6. You may create zombie processes while testing your codes, please make sure you kill them every time you want to run your code. To see a list of all zombie processes, try this command:

```
ps -aux | grep developer
```

   Identify the zombie processes and their process number and kill them by typing at the command-line:

```
kill -9 <process number>
```

REQUIREMENTS

1. Do not hardcode the TCP or UDP port numbers that are to be obtained dynamically. Refer to Table 3 to see which ports are statically defined and which ones are dynamically assigned. Use getsockname() function to retrieve the locally-bound port number wherever ports are assigned dynamically as shown below:

```
/*Retrieve     the  locally-bound  name of   the  specified
     socket and store it in the sockaddr structure*/
getsock_check=getsockname(TCP_Connect_Sock,(struct sockaddr
*)&my_addr, (socklen_t *)&addrlen);
//Error checking
if (getsock_check== -1) { perror("getsockname"); exit(1);
}
```

2. The host name must be hard-coded as **localhost (127.0.0.1)** in all codes.

3. Your client should terminate itself after all done. And the client can run multiple times to send requests. However, the backend servers and the AWS should keep running and be waiting for another request until the TAs terminate them by Ctrl+C. If they terminate before that, you will lose some points for it.

4. All the naming conventions and the on-screen messages must conform to the previously mentioned rules.

5. You are not allowed to pass any parameter or value or string or character as a command-line argument except while running the client in Phase 1.

6. All the on-screen messages must conform exactly to the project description. You should not add anymore on-screen messages. If you need to do so for the debugging purposes, you must comment out all of the extra messages before you submit your project.

7. Please do remember to close the socket and tear down the connection once you are done using that socket.

Programming Platform and Environment

1. All your submitted code **MUST** work well on the provided virtual machine Ubuntu.

2. All submissions will only be graded on the provided Ubuntu. TAs won't make any updates or changes to the virtual machine. It's your responsibility to make sure your code works well on the provided Ubuntu. "It works well on my machine" is not an excuse and we don't care.

3. Your submission MUST have a Makefile. Please follow the requirements in the following "Submission Rules" section.

Programming Languages and Compilers

You must use only C/C++ on UNIX as well as UNIX Socket programming commands and functions. Here are the pointers for Beej's Guide to C Programming and Network Programming (socket programming):

http://www.beej.us/guide/bgnet/

(If you are new to socket programming please do study this tutorial carefully as soon as possible and before starting the project)

http://www.beej.us/guide/bgc/

You can use a Unix text editor like emacs to type your code and then use compilers such as g++ (for C++) and gcc (for C) that are already installed on Ubuntu to compile your code. You must use the following commands and switches to compile yourfile.c or yourfile.cpp. It will make an executable by the name of "yourfileoutput".

```
gcc -o yourfileoutput yourfile.c
g++ -o yourfileoutput yourfile.cpp
```

Do NOT forget the mandatory naming conventions mentioned before!

Also inside your code you may need to include these header files in addition to any other header file you used:

```
#include <stdio.h> #include <stdlib.h> #include <unistd.h>
#include <errno.h> #include <string.h> #include <netdb.h>
#include <sys/types.h> #include <netinet/in.h> #include
<sys/socket.h> #include <arpa/inet.h> #include <sys/wait.h>
```

Submission Rules

Along with your code files, include a **README file and a Makefile**. In the README file write:

- Your **Full Name** as given in the class list
- Your Student ID
- What you have done in the assignment.
- What your code files are and what each one of them does. (Please do not repeat the project description, just name your code files and briefly mention what they do).
- The format of all the messages exchanged.
- Any idiosyncrasy of your project. It should say under what conditions the project fails, if any.

- Reused Code: Did you use code from anywhere for your project? If not, say so. If so, say what functions and where they're from. (Also identify this with a comment in the source code.)

SUBMISSIONS WITHOUT README AND MAKEFILE WILL BE SUBJECT TO A SERIOUS PENALTY.

About the Makefile

Makefile Tutorial:
https://www.cs.swarthmore.edu/~newhall/unixhelp/howto_makefiles.html

Makefile should support following functions:

Compiles **all** your files and creates executables	`make all`
Runs server A	`make serverA`
Runs server B	`make serverB`
Runs server C	`Make serverC`
Runs AWS	`make aws`
Query the AWS	`./client <Map ID> <Source Vertex Index> <Destination Vertex Index> <File Size>`

TAs will first compile all codes using **make all**. They will then open 5 different terminal windows. On 4 terminals they will start servers A, B, C and AWS using commands **make serverA**, **make serverB**, **make serverC**, and **make aws**. **Remember that servers should always be on once started.** Client can connect again and again with different input query arguments. On the 5th terminal they will start the client as "**./client <Map ID> <Source Vertex Index> <Destination Vertex Index> <File Size>**". TAs will check the outputs for multiple queries. The terminals should display the messages specified above.

1. Compress all your files including the README file into a single "tar ball" and call it: **ee450_yourUSCusername_session#.tar.gz** (all small letters) e.g. my filename would be **ee450_nanantha_session1.tar.gz**. Please make sure that your name matches the one in the class list. Here are the instructions:

   On your VM, go to the directory which has all your project files. Remove all executable and other unnecessary files. **Only include the required source code files, Makefile and the**

README file. Now run the following commands:
Now, you will find a file named "ee450_yourUSCusername_session#.tar.gz" in the same directory. Please notice there is a star (*) at the end of first command.

```
tar cvf ee450_yourUSCusername_session#.tar *
gzip ee450_yourUSCusername_session#.tar
```

2. Do NOT include anything not required in your tar.gz file. Do NOT use subfolders. Any compressed format other than .tar.gz will NOT be graded!

3. Upload "ee450_yourUSCusername_session#.tar.gz" to the Digital Dropbox on the DEN website (DEN -> EE450 -> My Tools -> Assignments -> Socket Project). After the file is uploaded to the drop box, you must click on the "**send"** button to actually submit it. If you do not click on "**send**", the file will not be submitted.

4. D2L will and keep a history of all your submissions. If you make multiple submission, we will grade your latest valid submission. Submission after deadline is considered as invalid.

5. D2L will send you a "Dropbox submission receipt" to confirm your submission. So please do check your emails to make sure your submission is successfully received. If you don't receive a confirmation email, try again later and contact your TA if it always fails.

6. Please take into account all kinds of possible technical issues and do expect a huge traffic on the DEN website very close to the deadline which may render your submission or even access to DEN unsuccessful.

7. Please DO NOT wait till the last 5 minutes to upload and submit because some technical issues might happen and you will miss the deadline. And a kind suggestion, if you still get some bugs one hour before the deadline, please make a submission first to make sure you will get some points for your hard work!

8. After receiving the confirmation email, please confirm your submission by downloading and compiling it on your machine. If the outcome is not what you expected, try to resubmit and confirm again. We will only grade what you submitted even though it's corrupted.

9. **You have plenty of time to work on this project and submit it in time hence there is absolutely zero tolerance for late submissions! Do NOT assume that there will be a late submission penalty or a grace period. If you submit your project late (no matter for what reason or excuse or even technical issues), you simply receive a zero for the project.**

GRADING CRITERIA

Notice: We will only grade what is already done by the program instead of what will be done. For example, the TCP connection is established and data is sent to AWS. But the result is not received by the client because AWS got some errors. Then you will lose some points for phase 1 even though it might work well.

Your project grade will depend on the following:

1. Correct functionality, i.e. how well your programs fulfill the requirements of the assignment, especially the communications through UDP and TCP sockets.

2. Inline comments in your code. This is important as this will help in understanding what you have done.

3. Whether your programs work as you say they would in the README file.

4. Whether your programs print out the appropriate error messages and results.

5. If your submitted codes do not even compile, you will receive 5 out of 100 for the project.

6. If your submitted codes compile using make but when executed, produce runtime errors without performing any tasks of the project, you will receive 10 out of 100.

7. If you forget to include the README file or Makefile in the project tar-ball that you submitted, you will lose 15 points for each missing file (plus you need to send the file to the TA in order for your project to be graded.)

8. If you add subfolders or compress files in the wrong way, you will lose 2 points each.

9. If your code does not correctly assign the TCP or UDP port numbers (in any phase), you will lose 10 points each.

10. You will lose 5 points for each error or a task that is not done correctly.

11. The minimum grade for an on-time submitted project is 10 out of 100, assuming there are no compilation errors and the submission includes a working Makefile and a README.

12. There are no points for the effort or the time you spend working on the project or reading the tutorial. If you spend about 2 months on this project and it doesn't even compile, you will receive only 5 out of 100.

13. **You must discuss all project related issues on Piazza**. We will give those who actively help others out by answering questions on Piazza up to 10 bonus points. If you want to earn the extra credits, do remember to leave your names visible to instructors when answering questions on Piazza. Also, you will NOT get credit by repeating others' answers.

14. The maximum points that you can receive for the project with the bonus points is 100. In other words the bonus points will only improve your grade if your grade is less than 100.

15. Your code will not be altered in any way for grading purposes and however it will be tested with different inputs. Your designated TA runs your project as is, according to the project description and your README file and then check whether it works correctly or not. If your README is not consistent with the description, we will follow the description.

FINAL WORDS

1. Start on this project early. Hard deadline is strictly enforced. No grace periods. No grace days. No exceptions.

2. In view of what is a recurring complaint near the end of a project, we want to make it clear that the target platform on which the project is supposed to run is *the provided* ***Ubuntu (16.04)***. It is strongly recommended that students develop their code on this virtual machine. In case students wish to develop their programs on their personal machines, possibly running other operating systems, they are expected to deal with technical and incompatibility issues (on their own) to ensure that the final project compiles and runs on the requested virtual machine. If you do development on your own machine, please leave at least three days to make it work on Ubuntu. It might take much longer than you expect because of some incompatibility issues.

3. Check Piazza regularly for additional requirements and latest updates about the project guidelines. Any project changes announced on Piazza are final and overwrites the respective description mentioned in this document.

4. Plagiarism will not be tolerated and will result in an "F" in the course.