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System Software Project Report

COMP20081

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# Introduction

A farmer wishes to use technology to improve his business. This is going to be done through a server that will gather necessary information from connected weather stations and then present this information to workstations (managed/ used by the farmers) connected to a central server machine to monitor important data necessary to improve the efficiency of the field. This data being temperature, barometric pressure, relative humidity, wind force etc. This central server will be responsible for extracting and storing the data from the weather stations when the system is powered up. The system would act the same as any other user system, requiring users to create accounts and log in to the system. Our Team has been given the job of creating this distributed system that will house all these features.

# Aims and Objectives.

The main aim of this group is to create the three main components of the application:

* A weather station client that collects and sends out accurate readings on temperature, barometric pressure, relative humidity, wind force etc.
* A user client which is password protected and is used to display data sent from the weather station client using a graphical user interface (GUI).
* A server that facilitates communication between the two clients mentioned above and includes a GUI of its own.

# Implementation:

## Protocol Choice: Research

**What is TCP?**

The Transmission Control Protocol (TCP) is a connection-oriented communications protocol that handles the interaction between devices in a network (sdxcentral, 2021).

TCP for the most part handles the breaking down of application data into packets, packet ordering and error checking for the IP protocol. It is responsible for assembling the packets of data that have been sent over the network.

When application data is broken down into packets, the packets are numbered and are sent off to the destination address. These packets will travel in a multitude of ways and so will be received in random order. And so, the TCP protocol correctly orders the packets before they are handed off to the application, and any packets that have not arrived will be requested to be sent again (allows for error free data transmission).

The TCP protocol maintains the network connection with the sender before the first packet is sent until after the final packet has been sent. Only once all packets have been transferred will the connection terminate (Cloudflare, 2021)(Lutkevich, 2020)**.**

**What is UDP?**

UDP takes application data and divides It into packets called datagrams. These are then sent out across the network. UDP does not reassemble or number the datagrams but the datagrams do include a header that includes the port numbers to help distinguish user requests. There is also an optional checksum that can be attached to the header of these datagram headers that can help verify the integrity of the data transferred (sdxcentral, 2021).

The User Datagram Protocol (Cloudflare, 2021) is used across the internet for time sensitive events. This includes events like Video playback and DNS lookups.

The UDP accomplishes this as it is a connectionless-oriented communications protocol. It does not establish a connection before the data packets are sent out. This speeds up the transfer speed for the data. Essentially for two computers in a network, one can simply start sending packets straight away to the other computer with no connection being established first.

But the packets can very easily be lost in transit which will not be sent out again. Applications made to use this communication protocol must be able to tolerate errors, loss, and duplication. The unreliability in this protocol creates opportunities for exploitation (DDOS attacks) .

## Protocol Choice: Decision

For our application, a lot of factors have to be taken into account. For instance, weather data is constantly changing and it's always a struggle to get accurate readings. For this reason, a speedy connection could be beneficial. However, you have to consider that UDP although it has a speedy data transfer (connection speed), it is not reliable. It is prone to data loss and in some cases data corruption. For the farmers to more efficiently run their business this data needs to be as accurate as possible without the data losses providing inaccurate results. This also applies to the login services as well, as user data would be vulnerable to these data losses and corruption. This weakness could be exploited. Not to mention the loss of personal user data goes against the data protection act. For these reasons the best connection type to use is TCP. It’s a slower connection but provides an error free data transmission. This overall would be more beneficial than a speedy connection.

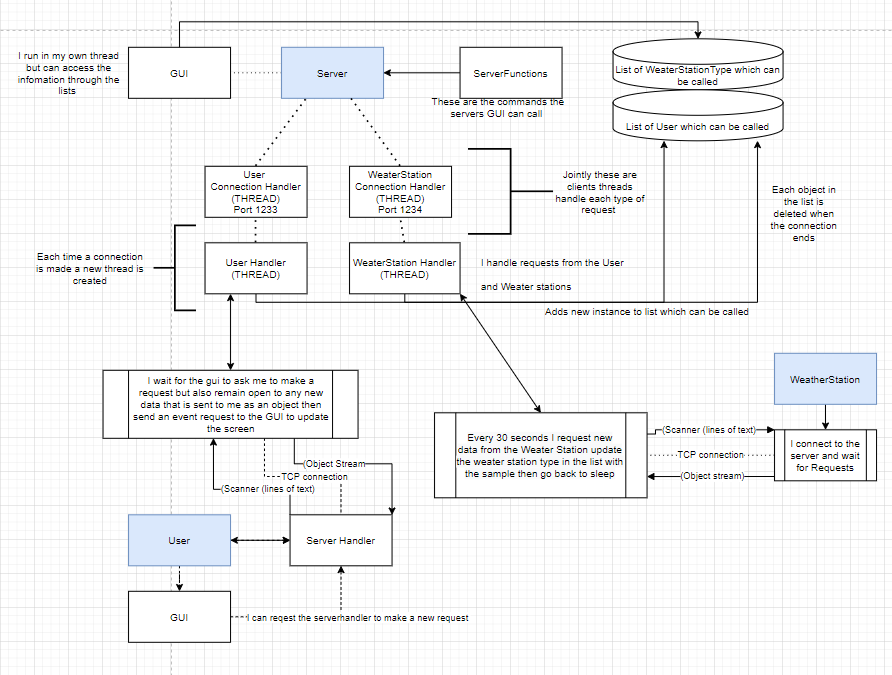
## How multithreaded client handling was implemented

To achieve multithreaded client handling, the server has two handlers, one for the user client and another for the weather client. When either client is run, a connection request will be sent to the server along with a port number which identifies the type of client that is sending the request. The server will then spawn a new thread that is tasked with handling that specific client.

User clients will not be able to attempt to connect to the server until they have first been granted authorised access to the system. This is achieved by the implementation of a registration system that utilises validation and encryption to ensure user security. The encrypted valid account details will be stored in a text file. One the user has logged in using valid credentials, the client will automatically be granted access to the server.

Weather station clients will automatically connect to the server when they are run, they will generate a unique ID which will be stored in a text file and used to identify a weather station so the user client can access the relevant data from the weather station corresponding with that ID value. For security purposes, ID’s will be randomly generated, if an ID is already taken the server will send a request to the weather station client for a new ID.

## Design

Our program uses runnable multithreading, the server runs three threads One for the GUI and two threads for handing each type of client (WS/User). When a client connects to the server the connection is accepted and a new thread is created to handle connection requests. Connections have an object stream and a scanner stream. We use the scanner stream for sending requests and the object stream for receiving responses.

We follow the principle of MVC (Model, view, and controller) data is stored within distinct datatypes which are also used to communication. Our GUI (view) is always running on its own thread it can request data and make requests to change data but following the principle of MVC this never happens in the GUI but instead happens within the main thread of the client or the server’s client handlers the GUI is able to call the thread. The data stored by the server about the clients are stored in two lists one for each client type. We use a synchronized list to store data.

## Connection Handling:

## Data Structures:

## Enhancements:

During the initial stages of planning our team knew that we wanted to be able to display parts of a weather station’s data using graphs/charts. Hence, we conducted some background research into potential libraries and found that xchart (Knowm Inc, 2021) was the ideal choice for this project. The application now charts a new graph based on the selected weather station using the sample data stored up until that moment. When the graph button is clicked again a new graph is plotted to include updates to the stored sample data. When a user switches to another weather station client and draws a graph, the graph updates to reflect the stored data of that specific weather station client instead.

[ Other enhancements -> account creation + credentials encryption for security ]

# Conclusion & Future Work:

Overall, the team believes that we have been able to successfully implement a concurrent client-server model using a TCP based network infrastructure to fulfil the project scenario’s requirements and aims.

The project includes two types of clients: the user and weather station client that can communicate by sending and receiving data in the form of objects with the help of the server. In addition to this basic level of functionality, the team was able to integrate a simple graphing system to plot a weather station’s temperature and humidity data on a chart for the user to be able to visualise the changes in the data over time. For this given scenario, this is especially useful as a Farmer’s may wish to present this data to investors to convince them that their land is of the ideal type to suit certain crops. Hence, a future update to this application would implement the ability to download and save the graphs as image files. This can be done through the graph’s java class and the user client’s GUI class so that on a click of a button it triggers a function to save the current graph on the user’s device.

Moving on, another feature the team would like to implement in the future is to swap out the random generation of sample data with actual sample data. To accomplish this, the team would need to make use web scrapping technology or external libraries that would allow for the asynchronous communication between our application and an actual weather station’s sensor. This would in turn improve upon the functionality of the code and convert the application into one that can be applied as an actual real-world solution.

In conclusion, the team is extremely proud of the project’s final outcome and that we have developed an application that fulfils its primary requirements in addition to including bonus features that enhance the overall user experience with the application.

# References

Cloudflare, 2021. *What is TCP/IP.* [Online]   
Available at: https://www.cloudflare.com/en-gb/learning/ddos/glossary/tcp-ip/  
[Accessed 18 April 2021].

Cloudflare, 2021. *What is UDP.* [Online]   
Available at: https://www.cloudflare.com/en-gb/learning/ddos/glossary/user-datagram-protocol-udp/  
[Accessed 18 April 2021].

Knowm Inc, 2021. *XChart - Knowm.org.* [Online]   
Available at: https://knowm.org/open-source/XChart/  
[Accessed 23 April 2021].

Lutkevich, B., 2020. *What is TCP.* [Online]   
Available at: https://searchnetworking.techtarget.com/definition/TCP  
[Accessed 18 April 2021].

sdxcentral, 2021. *What is Transmission Control Protocol (TCP).* [Online]   
Available at: https://www.sdxcentral.com/resources/glossary/transmission-control-protocol-tcp/  
[Accessed 18 April 2021].

sdxcentral, 2021. *What is User Datagram Protocol (UDP).* [Online]   
Available at: https://www.sdxcentral.com/resources/glossary/user-datagram-protocol-udp/  
[Accessed 18 April 2021].