

Armoured Warfare Simulator 2D 2014

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1 Analysis

1.1 Introduction

In 2013, a study by The NPD group showed that 68% of all PC owners used their computer for online gaming [1], making it the largest user base in the PC market. The problem comes with the fact that high-powered gaming machines are costly, and most users cannot play triple-A, high-fidelity releases on their home PC. This fact means that popular multiplayer games often leave some players unable to join in.

My client is Slick Muffin Studios[2], a small game developer who specialise in creating 2D games. I have worked with the client in the past, making small scale games. They have approached me to produce a multiplayer game in their style that can run on all machines made in the last 10 years in order to answer a growing request from the userbase for a game they can play with friends. My point of contact to the company is the creative director Jessie Canfer who has been with the company since it's founding in 2012.

My user group includes those who cannot play the full release of a game due to the machine specifications required to run it at a reasonable frame per second count. These potential consumers vary greatly in technical knowledge, from expert to beginner, although all know how to use a basic program.

In short, my aim is to produce a well-optimised 2D multiplayer game able to run on most systems.

1.2 Investigation of User Needs and Acceptable Limitations

1.2.1 The Current System Analysis

The problem that I am solving is that there is no current system- the user cannot play multiplayer games on their PC at a reasonable FPS. As such there is no current system to analyse.

1.2.2 Questionnaire

I asked various PC owners about their computer usage and specifications of their machines. This will help me set my limitations. Due to my user group, some may have lower specification PCs than others; In order to provide to all users, I will need to establish to lowest specification.

Question	User 1	User 2	User 3	User 4	User 5
Do you own a PC?	Yes	Yes	Yes	Yes	Yes
Do you play online games?	No	Yes	Yes	Yes	Yes
Do you have a dedicated graphics card?	No	No	No	Yes	No
Can you play new releases?	N/A	Yes(barely)	No	Yes	No
Are graphics important to you?	No	No	No	No	No
What operating system do you use?	GNU/Linux	Win8	Win7	Win8	WinVista

From this I have found out that graphics are not an issue in the games my users play, I expected this as the users want to play the games and cannot normally, as shown by the fact that 3/4 users have trouble playing new releases. I have also found that my system will have to be compatible with windows versions Vista onwards, as everyone interviewed uses windows, as well as other major operating systems including GNU/Linux.

1.2.3 The Proposed New System Analysis

I will interview a potential user of my solution, from it I hope to figure out what the average user enjoys and wants from a multiplayer game. I also hope to find out what style of game is enjoyable on low-end computers, to give me direction designing my solution.

Interview with Fuego Gitano, low-end PC user

Q: What is most important to you in a multiplayer game?

A: I want fun mechanics with a small-ish team size, also a reliable connection - it's not fun having lots of lag. There should be end-game content to keep players interested as well.

Q: End-game content? What do you mean?

A: I rather like progression, working up to gradually better things, but once you reach the top there is nothing else to do. More content when you reach this end keeps me interested and playing.

Q: What graphics do you expect from a multiplayer game?

A: From my machine, I expect at least a detailed or stylised 2d environment, 3d isn't always reliable as my FPS can drop quite a bit. Other than that, a simple style works quite well.

Q: What genres of game do you think work well for multiplayer?

A: I enjoy shooters and games involving individual skill. I also like fast-paced gameplay.

Q: Do you like luck being a mechanic of the game?

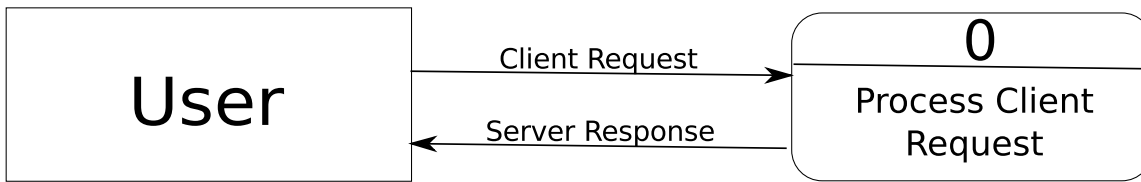
A: No, that ruins it for me. I like predictable gameplay .

Q: Is there anything else you enjoy in multiplayer games?

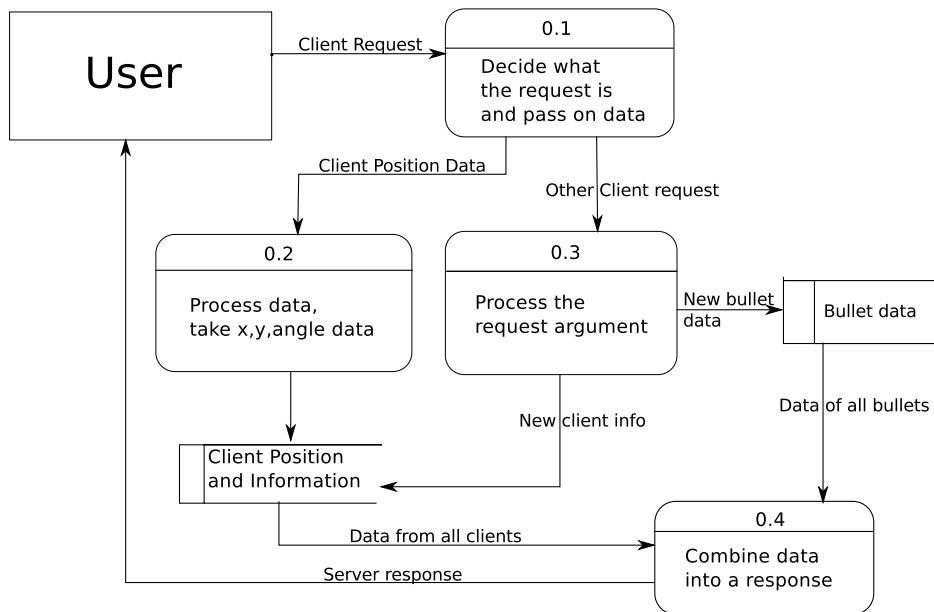
A: I enjoy an element of customisation, visual mainly. Strategy is also fun, quick decisions leading to either victory or defeat can be really good. Also winning should be secondary to having fun, and the game should allow for this by not focusing too much on victory. That is everything, I think.

From this interview I have found that my typical user puts emphasis on mechanics over graphics, which I expected as my user group does not have dedicated graphics cards, so have come to appreciate good mechanics. The user also wants there to be reason to carry on playing, to progress and to have something to work towards, this works nicely as the user enjoys shooters and progression is a mainstay in this genre. This combined with the user wanting a strategic game leads me to propose a top-down 2D armoured warfare game. It's will comprise of small-sized teams of perhaps 4 and an element of customisation as per the user's answers from the interview.

Level 0 Data Flow Diagram



Level 1 Data Flow Diagram



There is only one entity in my data flow diagram, as information is both taken from and given to the client. There are to be multiple clients entities connected to the server at one point, up to 8. The server will act as a data source, holding data for all connected clients and sending it to them on request.

Data will be stored on the server for user accounts, this will be a <10MiB database, and on the client side player sprites will be stored in PNG format for transparency, whilst the maps will likely be stored in JPG format along with a text file to store map collision data, i.e. where building are. These sprites could take up between 10 and 20 MiB of data, and the client/server collection will be under 30MiB. It will be able to be stored on any medium due to this size.

1.2.4 Data dictionaries

Below are the data dictionaries for my proposed system

Login database

Field name	Field purpose	Field Type	Example Data	Validation
Username	To store the users alias	String	FloatingGhost	Not null
Password	To enable secure login	String/Hashed	640ab2bae07bedc	Not null
XP	To store the user's progress	Int	7	Not null
Tanks	To store the user's unlocked tanks	String	PanzerIV,Maus	Not null
Wins	To store the users number of wins	int	7	Not null

Server variables

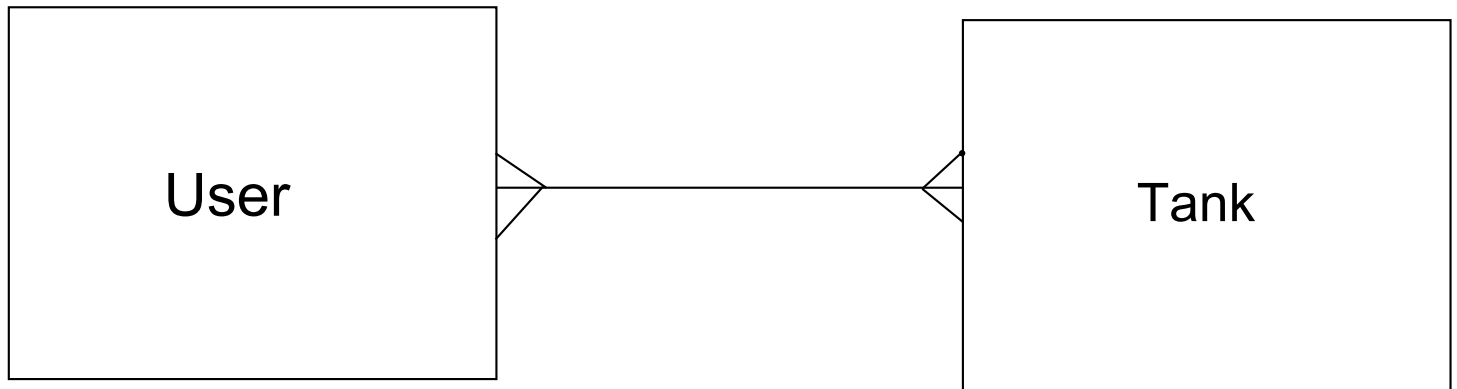
Field name	Field purpose	Field Type	Example Data	Validation
Id	To determine which client is connected	Int	7	Not null
x_pos	To store the clients x position	List of floats	[7.7,7.7]	Not null
y_pos	To store the clients y positions	List of floats	[7.7,7.7]	Not null
angles	To store the clients angles	List of floats	[77,77]	Not null
turret_angles	To store the clients turret angles	List of floats	[77,77]	Not null

Client variables

Field name	Field purpose	Field Type	Example Data	Validation
Id	To tell the server who you are	Int	7	None
x_pos	To draw every player on the screen	List of floats	[7.7,7.7]	None
y_pos	To draw every player on the screen	List of floats	[7.7,7.7]	None
angles	To draw every player on the screen	List of floats	[77,77]	None
turret_angles	To draw every player on the screen	List of floats	[77,77]	None
networkComms	To communicate with the server	Custom class	((("localhost",9999))	None

1.2.5 Database design

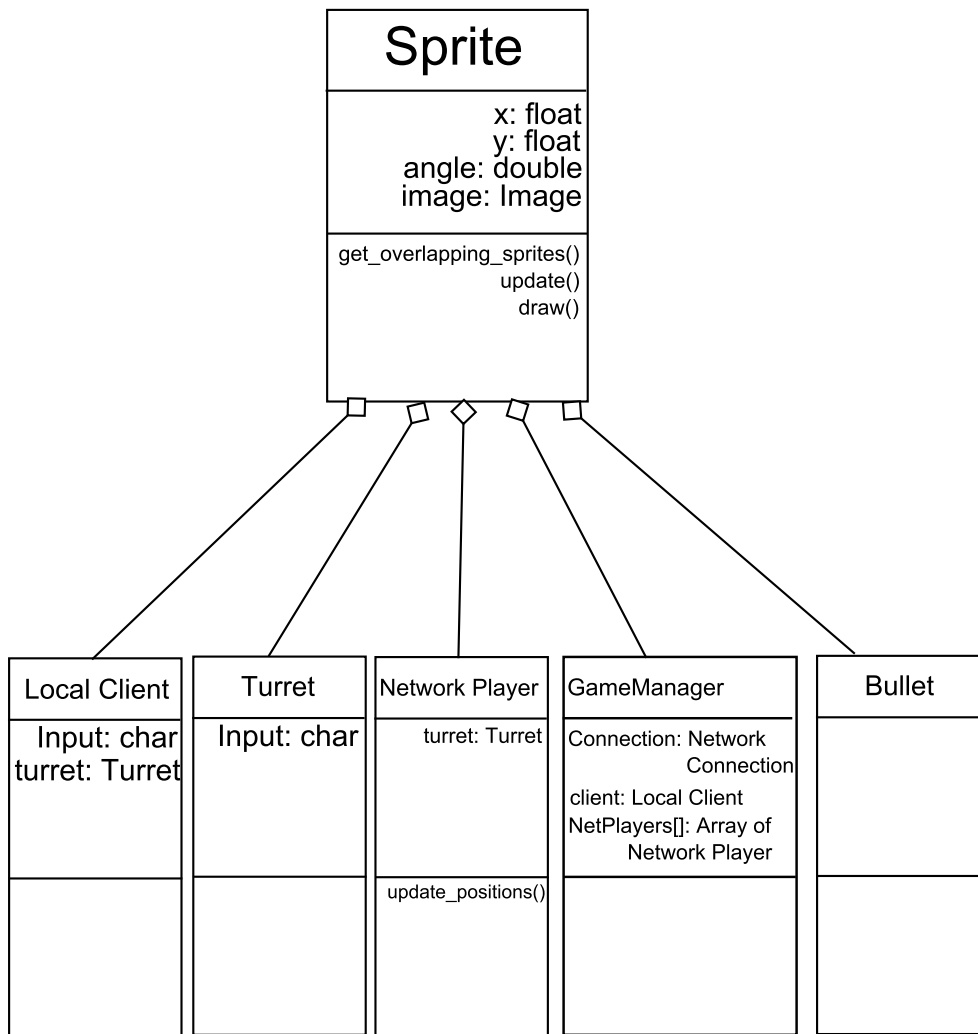
Main database design



User(UserID, username, hashedPassword, panzerIVProgress, churchillProgress, ... , [Tank]Progress, xp)

Tank(TankID, name, speed, hp, traverseSpeed, turretTraverseSpeed, damage, rateOfFire, armour, penetration)

1.2.6 Proposed objects



1.2.7 Data Sources and Destinations

Sources	Destinations
Player send client information	Server stored updates client information
Server send all player information	Player updates the network players, output in form of drawing players on t
Tank Database gives the tank stats	Client takes it's stats to correctly update it's own information, no out
Player gives input to the client	Outputted to the server in the form of updates client information

1.3 Constraints

1.3.1 Hardware

This is the main constraint of my proposed system as the problem I am solving is due to low-powered hardware. My solution will have to run on low-end integrated graphics systems at >30 FPS to fit with the client's request as expressed in the interview. It must also be able to host the server on both WiFi and Ethernet LAN to cover every possible machine.

Another possible hardware constraint is network interfaces - as the game will run over a network, it will need low latency to give a pleasant experience. Low-speed network interfaces are an issue due to the time taken for the client to send and receive requests and responses respectively from the server.

1.3.2 Software

My proposed system is to be cross-platform, so it must use a programming language that is also cross-platform as well as any external libraries.

1.3.3 Time

The project must be finished by the deadline, easter 2014.

1.3.4 User's Knowledge Of Information Technology

As my user group mainly plays games online, they are familiar with how to use a program. But to ensure that everyone on all systems can use my solution, I will keep the program as jargon-free as possible and as simplistic as I can make it.

1.3.5 Who will be allowed to use the system?

The client can be used by anyone, whilst the running server can only be accessed by the owner of the PC running it. User accounts can only be accessed by their respective owners, so there will have to be some way to log in to ensure security.

1.4 Objectives

1.4.1 General Objectives

My client's overall objective is to create a fun, multiplayer armoured warfare game that has depth and end-game content. My client wants it to run on any system, regardless of computer specification, whilst making the game to the users satisfaction.

1.4.2 Specific Objectives

1. By deadline day, my game client must be able to communicate across the network with low latency.
2. By deadline day, it must also be able to run on a low-power PC at more than 30 Frames Per Second.
3. By deadline day, it must also have user accounts with progression.
4. By deadline day, it must also support up to 8 players.
5. By deadline day, it must also be supported on Windows and Linux with less than a 5 minute installation time.

1.5 Consideration of Alternative Solutions

- I could use an alternative language such as Java as it is in common use, installed on almost all PCs and is cross platform. This would fit my specification as the language is compiled, making it run more effectively on low-end computers. I am also familiar with the language and how to create games in it, although networking is one of the hardest features of Java.
- I could use a WYSIWYG game creator such as gamemaker as it is simple to use and speeds up production significantly. It is also easy to learn and has networking extensions to allow for ease of creation.

1.6 Justification of Chosen Solution

I have chosen to use Python with PyGame for the client and pure Python for the server, whilst using wxPython for the GUI forms, such as the server configuration form. This is due to my knowledge of the language and the ease of networks with inbuilt modules. PyGame also makes game design more intuitive and efficient, making it able to run on most any PC. wxPython is a cross-platform GUI toolkit that includes a WYSIWYG designer and python modules, making the creation of GUI forms simpler.

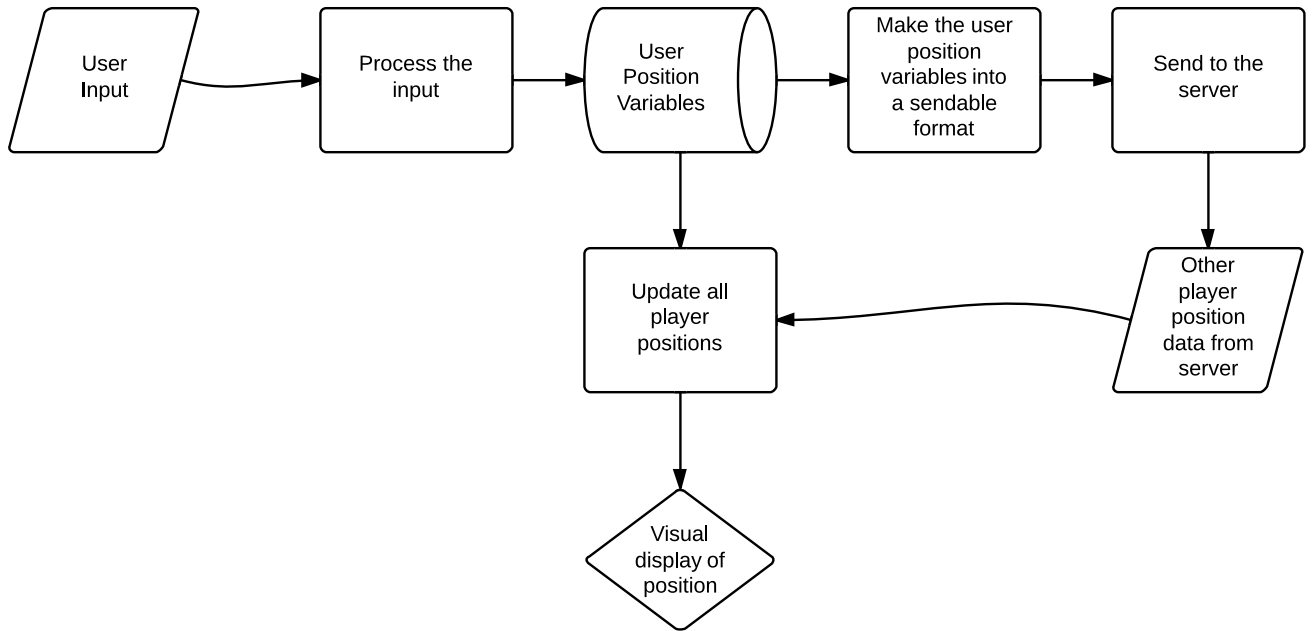
2 Design

In this section I shall outline my proposed system and its components, and explain how I shall implement each part of the solution.

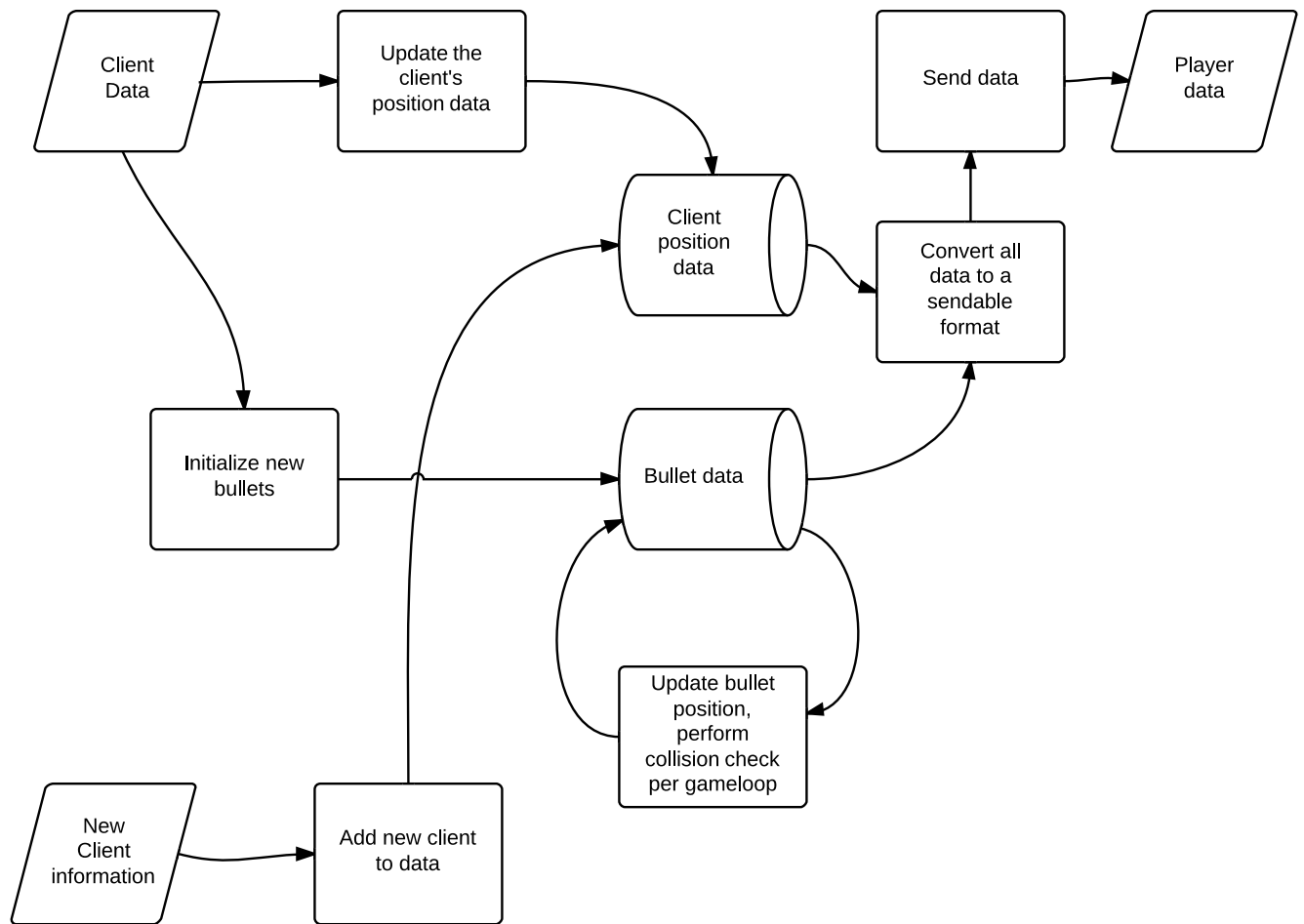
I shall start with an overall system overview, then go into more depth on the different parts of the system.

2.1 Overall System Design

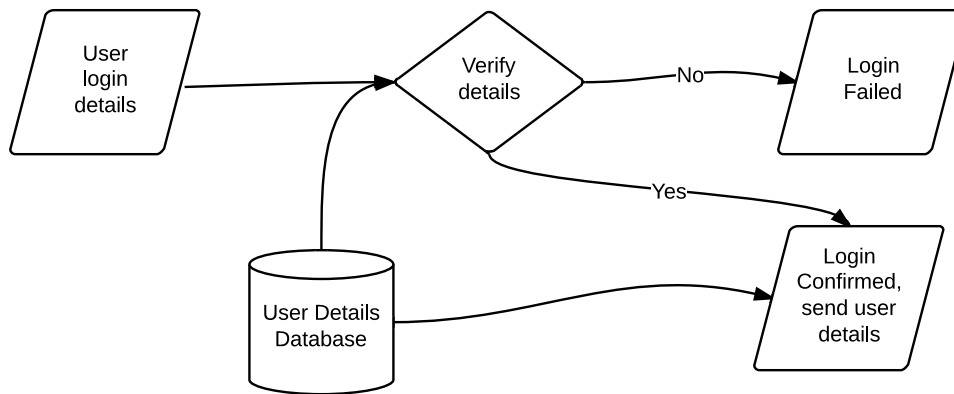
Client Side



Server Side

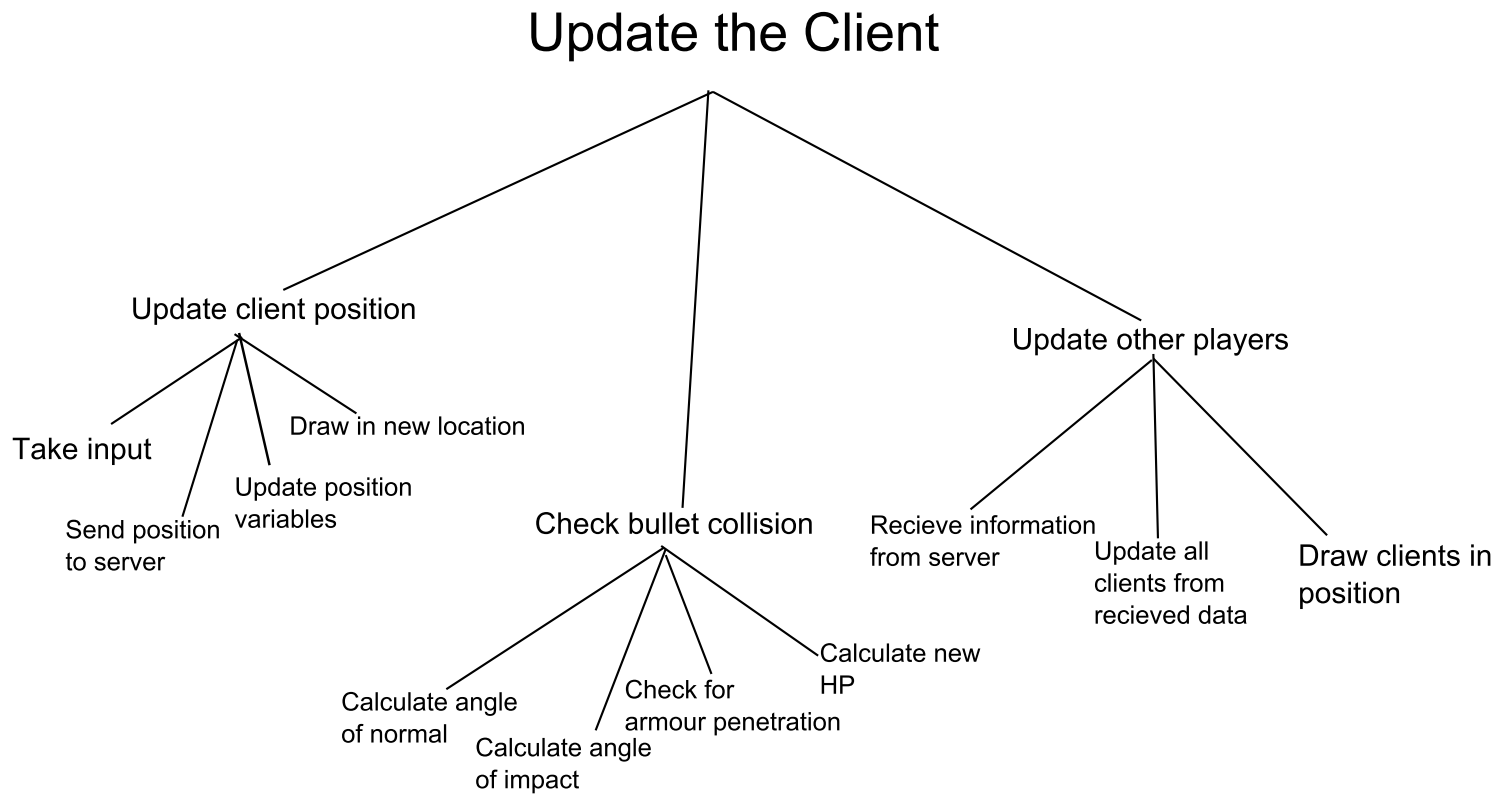


Login Server



2.2 Description of Modular Structure of System

Top-down design for the system



IPSO Table for the proposed system, server-side:

Inputs	Processes
Username	Sign in player
Password	Search for player in database
Tank Choice	Process the client request
X position	Calculate bullet trajectories
Y position	Calculate if the bullet penetrates
Hull angle	Calculate the HP of hit tanks
Turret angle	Update all connected players
Bullet creation	Update bullet position
Client Request	Calculate angle of bullet impact
Client connection	
Outputs	Data Stores
Client positions	Client information
Bullet positions	Bullet information
Client HP	User information (stats)
Client XP and progress	
Network response	
Local server information	

2.3 Definition of data requirements

A table of a database is used to store the details of the users. It uses this structure:

UserID: Integer
 Username: String[20]
 HashedPassword: String[100]

Another table is used to store the user progress on every tank, with the following structure:

UserID: Integer
 PanzerIVProgress: String[30]
 .
 .
 .
 ChurchillProgress: String[30]

The various tanks are stored in a third table with this structure:

TankID: Integer
 Name: String[10]

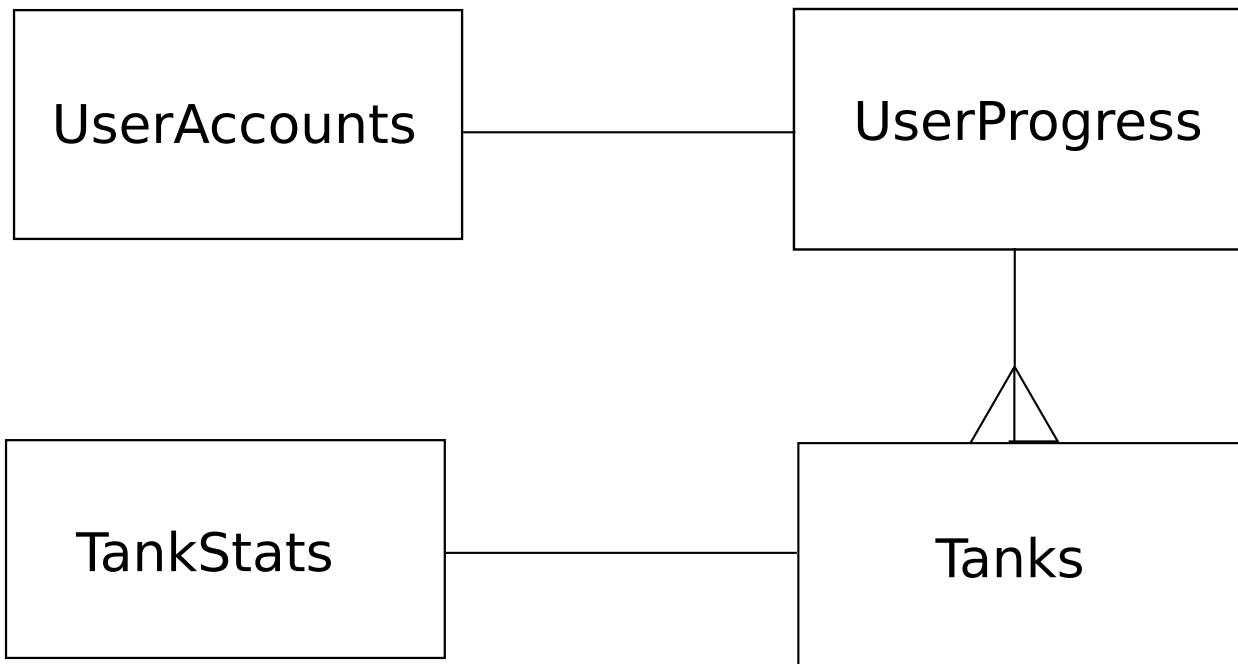
The stats for these tanks are stored in a final table with structure:

TankID: Integer

speed: Float
hp: Integer
traverseSpeed: Float
turretTraverseSpeed: Float
damage: Integer
reload: Integer
armour: Integer
penetration: Integer

The user tables will hold approximately 200 records based on the current user base of Slick Muffin, my client, and the tank tables will hold around 20 records.

2.4 Database Design



UserAccounts(UserID, Username, HashedPassword)

UserProgress(UserID, PanzerIVProgress, ChurchillProgress, (etc) [Tank]Progress)

Tanks(TankID, Name)

TankStats(TankID, speed, hp, traverseSpeed, turretTraverseSpeed, damage, reload, armour, penetration)

2.5 Storage

2.5.1 File Organisation and Processing

From my data dictionary, my database will likely require less than 5 MiB of storage space based on 200 users, although this could scale if the game is more popular than expected. As such I shall estimate the absolute maximum size to be 10 MiB. The game resources (pictures, sound etc.) will take up quite

a bit more room. Going on 20 tanks, I predict the total resources size to be approximately 30-50 MiB dependant on the quality of sound used.

An estimate for the final program file size would be around 60 MiB for absolutely everything.

2.5.2 Identification of Storage Media

My files will be stored on a hard drive, with data written and read in the working directory to avoid permission complications with Windows. I will use a complete backup on the server side, every day the server is online it will be copied to make a new file in the users home directory.

2.6 Identification of suitable algorithms

A large part of my game revolves around armour penetration mechanics, I.E if the bullet damages the vehicle or not. This is largely dependant on the bullet's angle of impact to the surface of the tank.

Definition 2.1. Henceforth, $\mathbf{A} \cdot \mathbf{B}$ shall be used to denote the dot product of vectors \mathbf{A} and \mathbf{B} , where the dot product is defined as

$$\mathbf{A} \cdot \mathbf{B} = A_1 B_1 + A_2 B_2 = |\mathbf{A}| |\mathbf{B}| \cos \theta$$

Where θ is the angle between the 2 vectors, and $|\mathbf{A}|$ is the modulus or length of the vector given by:

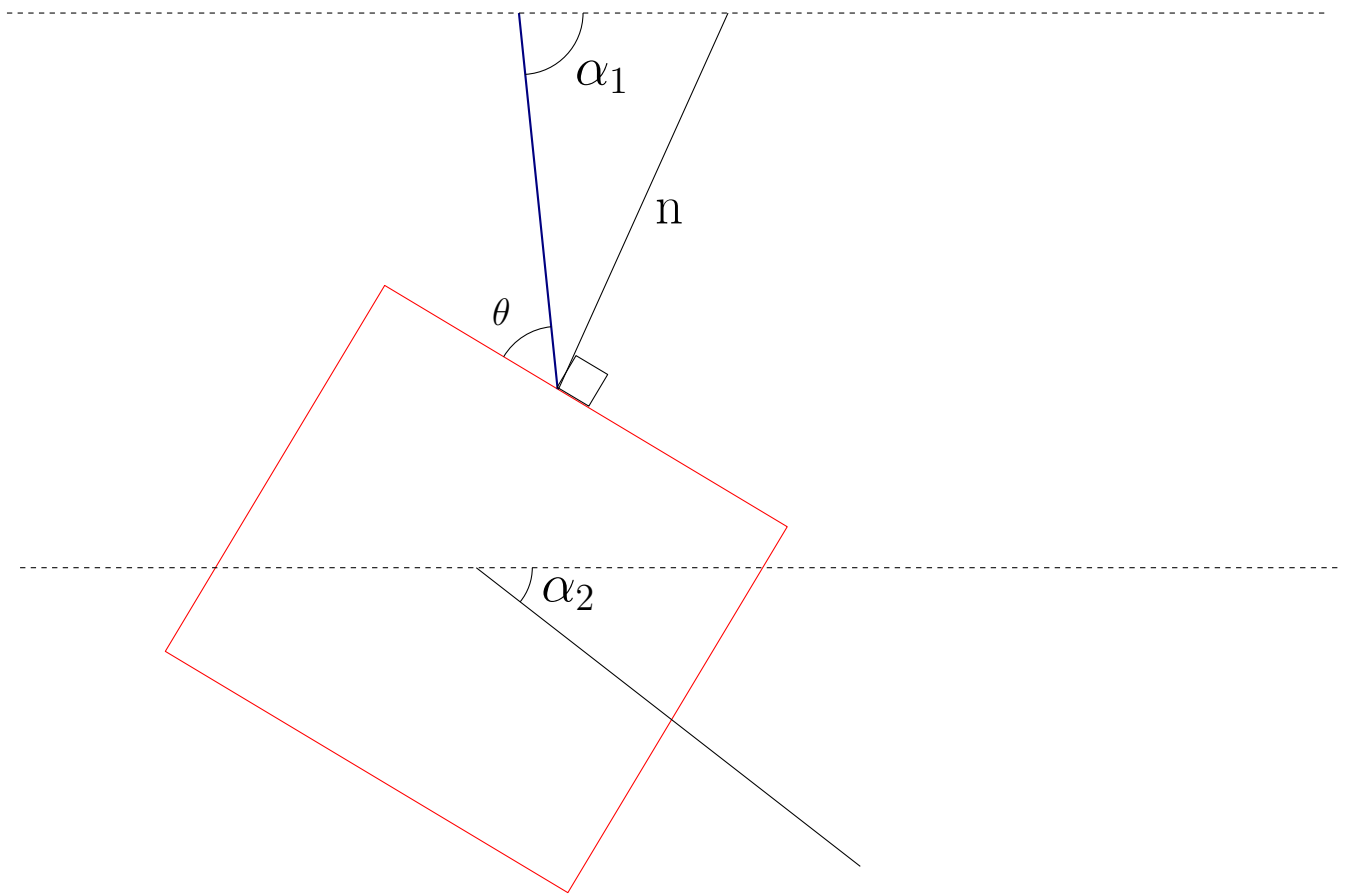
$$|\mathbf{A}| = \sqrt{A_1^2 + A_2^2}$$

Hence:

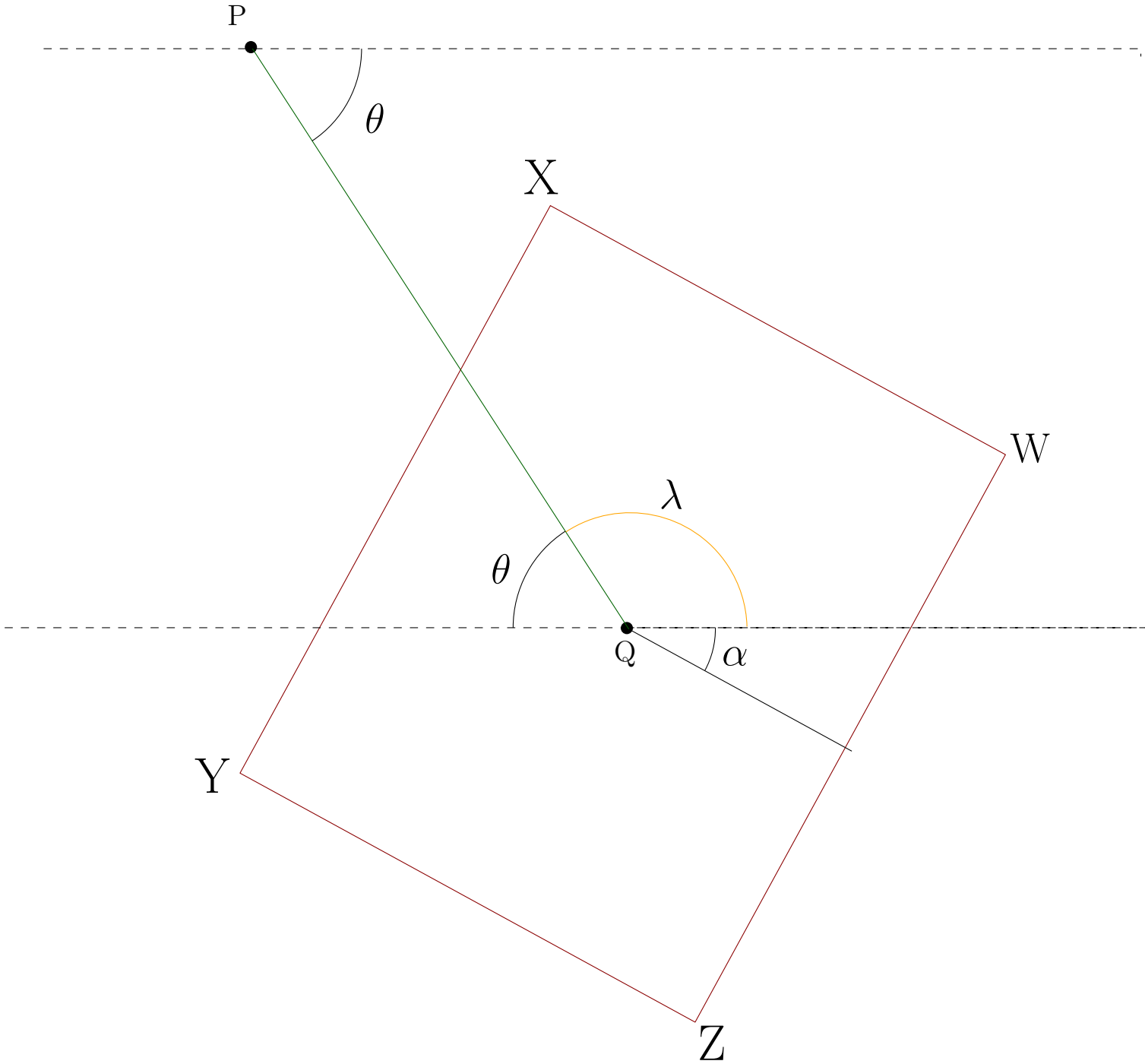
DotProduct :

```
VecA <- Input VectorA
VecB <- Input VectorB
xComponent <- VecA.x * VecB.x
yComponent <- VecA.y * VecB.y
output xComponent + yComponent
```

Suppose we have a tank at angle α_2 and the velocity vector of the bullet hitting it, with the angle of the velocity vector α_1 , I.E:



n is the normal to the surface of impact, and it's angle is dependant on the bullet's location.



Consider the above diagram, from it we can create an algorithm that will return the angle of the normal to the surface. From the diagram, it is shown that the angle from the line PQ and the line running perpendicular through the tank is $180 - \theta + \alpha$ where θ is the angle of the bullet from the positive x-axis and α is the angle of the tank from the same axis.

From this we want to find what angle the normal is in reference to the bullet, as if it hits the top surface it is at a different angle to if it hits the side.

This angle will differ based on the size of the tank's hit box, so henceforth I will use TW to denote tank width and TH to represent tank height, with the horizontal on the above diagram running through the TW side.

We will need to find where the corners of the tank are in order to have any reference to the bullet,

a will be used below to denote the angle the tank is facing.

- Corner Z is given by $\arctan[(TW/2)/(TH/2)]+a$
- Corner Y is given by $\arctan[(TH/2)/(TW/2)] +a$
- Corner X is equal to the angle to corner Z + 180
- Corner W is equal to the angle to corner Y + 180

So, finally, the angle of the normal is this:

Normal:

```

angleOfTank <- Input Tank.Angle

angleOfBullet <- Input Bullet.Angle

angleBetween <- 180 - angleOfBullet + angleOfTank

toCornerZ <- arctan [(TW/2) / (TH/2)]

toCornerY <- arctan [(TH/2) / (TW/2)]

if angleBetween < toCornerZ
    output angleOfTank

else if angleBetween < toCornerY
    output 90 + angleOfTank

else if angleBetween < toCornerZ + 180
    output 180+ angleOfTank

else
    output 270 + angleOfTank

```

Definition 2.2. So if we consider finding the general angle of impact, taking into account the angle of the normal, we can use the following algorithm:

AngleOfImpact:

```

Bullet <- Input bullet

BulletXComp <- Bullet.Velocity * cos(Bullet.angle)

BulletYComp <- Bullet.Velocity * sin(Bullet.angle)

BulletVector <- Bullet.Velocity * Bullet.angle

```

```

NormalLine <- Normal(Input Tank)

NormalLength <- 2

NormalXComp <- NormalLength * cos(NormalLine)

NormalYComp <- NormalLength * sin(NormalLine)

Dot <- DotProduct(BulletVector , NormalLine)

ModA <- sqrt [( BulletXComp^2) + BulletYComp^2)]

ModB <- sqrt [( NormalXComp^2) + (NormalYComp^2)]

CosTheta <- Dot / (ModA * ModB)

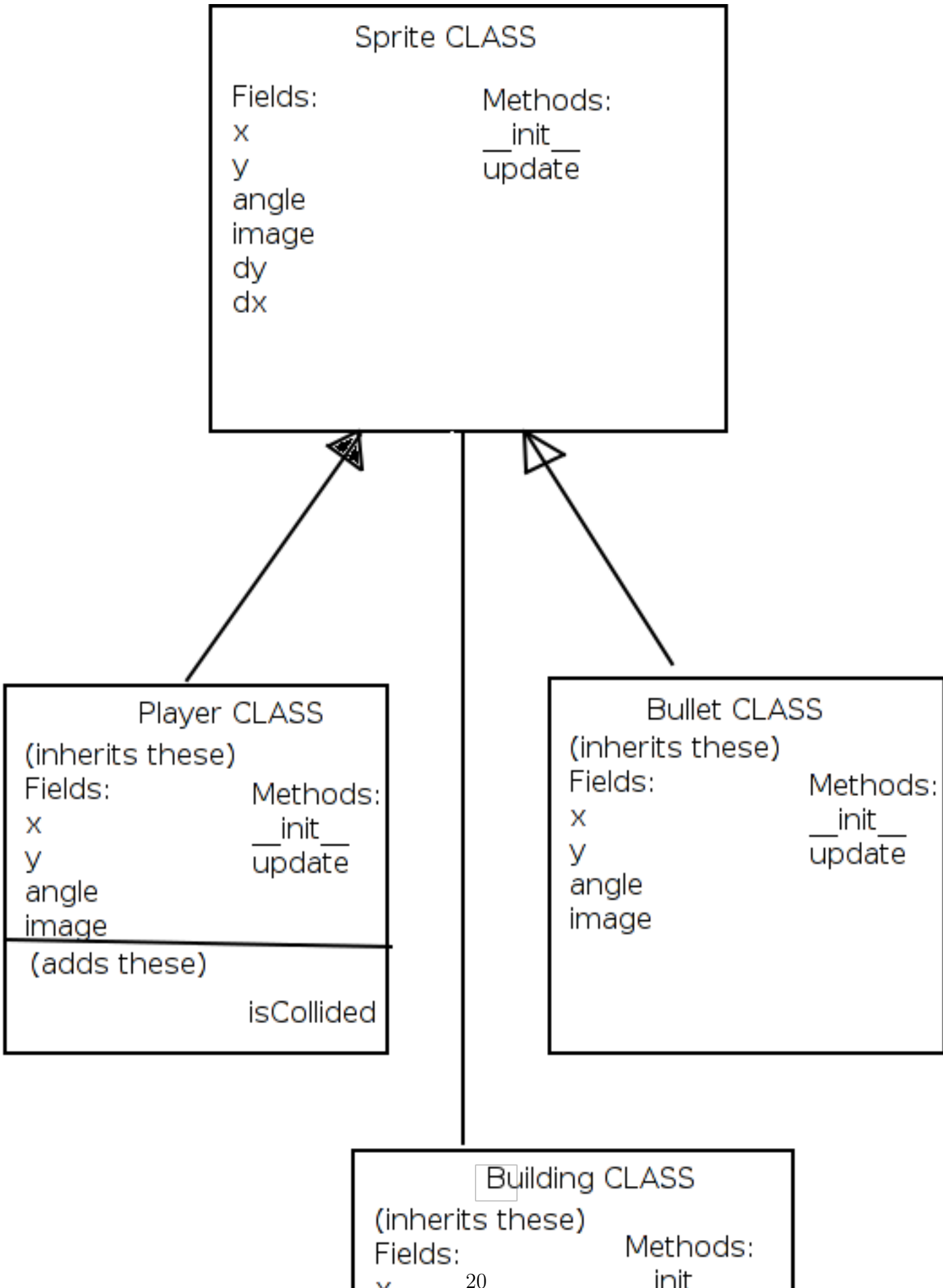
Output arccos(90 - CosTheta)

```

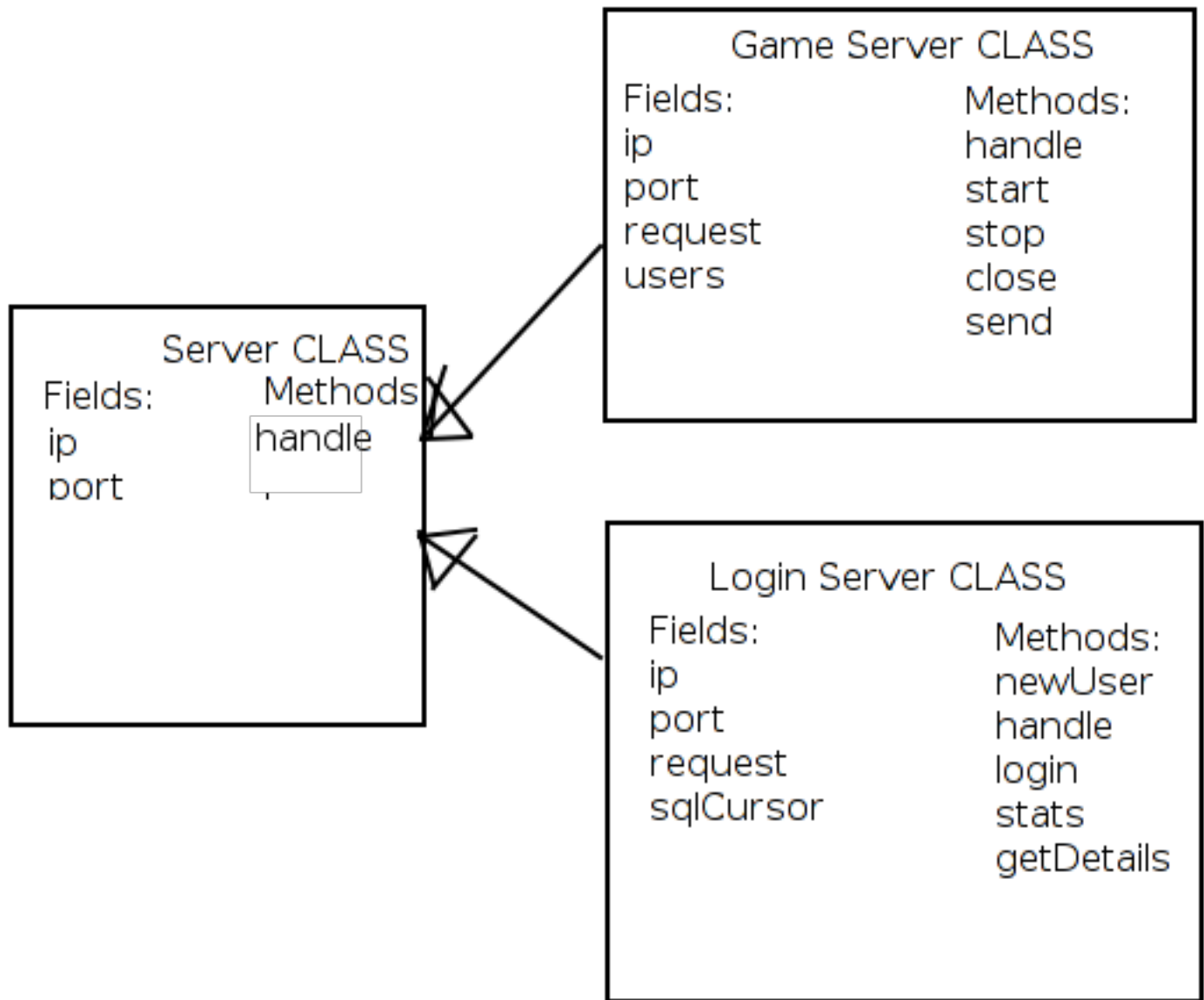
2.7 Class definitions

In this section I will use diagrams to explain my planned class structures.

2.7.1 Sprite Classes



2.7.2 Server Classes



2.8 User Interface Rationale

For my GUI, I shall be using as simplistic a graphics scheme as possible as the client wants the program to run on very low-powered computers and a complex GUI could possibly not run as well as intended. As such, I shall be using the default graphics scheme of the wx toolkit as it is the best optimised. I shall use a sans-serif font that can be rendered on all operating systems, the font will be Open Sans due to its clarity on smaller displays.

For multiple choice options I shall use drop-down lists as they save space, allowing for more to be on one form.

The main game shall be in 1024x768 resolution, it is universally supported which the client has said is a requirement. The other forms shall be no larger then 600x400 to avoid lack of screen space if multiple forms need to be displayed at once.

2.9 UI Sample of Planned Data Capture and Entry Designs

The main tank selection window:

Username and XP
to clearly show the
user's progress

Horizontally aligned
text and input for ease of
use

Upgrade
button clearly
next to stats
to avoid
confusion

Simple colour
scheme to work
on all machines

Armoured Warfare Simulator 2014

[Username] [Amount of XP]

Select a Tank: PanzerIV

Tank Stats:

HP: 400
Damage (HP average): 100
Penetration (mm): 110
Reload (ticks): 200
Armour (mm): 40
Hull Traverse Speed: 1
Turret Traverse Speed: 1
Speed: 1

Upgrade

Server Address:Port: localhost:9999

Roll out!

Clear button to
start the game.
easy to find

Default value to
let the user know the
format of input

2.10 Description of measures planned for security and integrity of data

As this project is network-based, the majority of the errors come from the connection between client and server. As such user input much be validated to ensure the network connections can be carried out without error, and the "Server join" box will run a check on the input to make sure that there is a server address and that this address is reachable.

Error messages resulting from the connection will look like this:

Error

There was an error hosting the server. Please wait a few minutes and try again.



Error hosting on address: [Host]:[Port]

Error

The client was not able to join the selected server. Please check that the address is correct.



Error joining server [Host]:[Port]

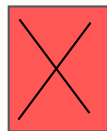
Error

The server has unexpectedly closed the connection. Please check your internet connectivity and try reconnecting.



Error

I require a host and port to connect to the server.
Please input this in the form
HOST:PORT as given to you by
the server owner.



All of these errors are not recoverable directly by the program and will put the user back at the main GUI for either the server or the client for reconnection or the erroneous data to be modified, in the case of the HOST:PORT error.

2.11 Description of measures planned for systems security

The client has specified that they would like user accounts, and as such these must be secure to avoid tampering. The user database will be stored on a central server with passwords hashed using SHA-1 which is inaccessible to anyone except for the owner of the login server, the client. This ensures security of user data and progress whilst providing a central data storage location for the program to use.

Security of client-hacking is carried out through mainly server-side calculations, meaning that any modification of local code will not affect the game experience for anyone else.

2.12 Overall Test Strategy

Series	Purpose of Test Series
1	Population of the GUI - client data and network interfaces. (System Testing)
2	Network connection, do the client and server connect and stay connected? (Integration testing)
3	Database information transfer, does the client receive the correct information? (System Testing)
4	Physics of bullets - do armour penetration calculations work? (White box testing)
5	Client draws the game correctly - do the graphics appear the same on all clients? (System testing)

3 System Maintenance Document

In this section I will overview how my system works, first generally, then per-algorithm.

3.1 System Overview

Armoured Warfare Simulator 2014 is an online multiplayer game that takes simple shooting mechanics and turns them into a strategic game of angles. It is run over a peer-to-peer network with anyone able to host a server and start playing with their accounts which are handled on a unified login server, keeping track of progress on each account.

I have designed the system to only have trivial tasks for the end-user, as this allows anyone to use the system. The only non-trivial task in my program is the “updateAllSettings.py” script for moving login server location. The client/server settings can be updated by entering the new login server IP address (string) and the port (integer) into the terminal.

The data in my system is stored in 2 sqlite3 databases, one is clientside and holds the base tank statistics and the other is serverside, holding all user information and progress made.

3.2 Sample algorithms

3.2.1 Angle of Intersection

```
def getAngleOfIntersection(vecA, vecB):  
    """a dot b / mag(a) mag(b)"""  
    try:  
        # Set numerator and denom  
        num = vecA.dotProduct(vecB)  
        denom = vecA.getMagnitude() * vecB.getMagnitude()  
        # Angle is  $\cos^{-1}(A \cdot B / |A||B|)$   
        ang = math.degrees(math.acos(num / denom))
```

```

        return ang
    except Exception as ex:
        print "Exception in getangleofintersection: " + str(ex)

```

Line by line explanation of the algorithm 1. Define algorithm getAngleOfIntersection, taking parameters vector A and vector B

2. The documentation for the algorithm, describes the use.
3. Try the below code and check for errors
4. Set num to be the dot product of vector A and vector B (See 2.1)
5. Set denom to be the magnitude of A multiplied by the magnitude of B
6. Comment explaining that the angle is the inverse cosine of num/denom
7. Calculate the angle of intersection
8. Return the result.

3.2.2 Login Procedure

```

def login(self, dat):
    """Compare the users credentials to the database and login if they match"""
    #Check if these credentials are in the database
    if len(LogServer.cur.execute("""SELECT UserInfo.UserName FROM UserInfo
INNER JOIN UserPass ON UserInfo.UserId=UserPass.UserId
WHERE UserInfo.Username=? AND UserPass.HashPass=?""", dat).fetchall()) > 0:
        userId = LogServer.cur.execute("SELECT UserId FROM UserInfo
                                         WHERE Use

        print "ID LOGGING IN: " + str(userId)
        a = (LogServer.cur.execute("""SELECT UserInfo.Username, UserProgress.*, UserO
INNER JOIN UserProgress, UserOwned
                                ON UserInfo.UserId = UserProgress.UserId
AND UserInfo.UserId = UserOwned.UserId
                                WHERE UserInfo.Username = ?;""", [dat[0]]

        self.request.sendall(pickle.dumps(a))
    else:
        print "Login failed"
        self.request.sendall(pickle.dumps("LoginFailure"))

```

1. Define a new function, login that takes argument dat
2. Documentation string
3. Comment
4. Query the database for matching credentials
5. Set userId as the database stored unique identifier associated to the username
6. Print a message logging that a login attempt has been succesful
7. Set a as the database stored info for the user's progress
8. Send the user progress back to the client
9. If there are no matching credentials:
10. Log that a failed login attempt has been made
11. Tell the client that login was unsuccessful.

3.2.3 Get rebound angle

This is an excerpt from get() in server.py

```

#If bullets don't pen, they should rebound
if len(req[4]) > 0:
    for bid in req[4]:
        id = bid[0]
        angleOfImpact = bid[1]
        angleOfNormal = bid[2]
        angleOfBullet = bid[11]
        anglePointingAway=(angleOfBullet + 180) % 360
        angleToNormal = math.fabs((angleOfNormal - anglePointingAway) % 360)
        newAngle = (anglePointingAway + (2 * angleToNormal)) % 360
        for b in TankServer.Bullets:
            if b.bulletID == id:
                toEdit = b
                toEdit.angle = newAngle

```

1. Comment for documentation
2. If req[4] (list of bullets the client has said should rebound) has elements:
3. the bullet identifier is stored to ID
4. The client calculated angle of impact is stored
5. The client's normal angle is stored
6. The angle the bullet is pointing is stored
7. For calculations, we store the opposite angle of the bullet, i.e. it's angle - 180
8. We calculate the absolute angle from the normal to the angle of the bullet
9. We use this calculated difference to find the new angle of the rebounded bullet
10. Iterate through the bullet array
11. If we've found the right one, do something
12. Save the needed bullet entity
13. Change the angle of the bullet.

3.2.4 Map Generation

```

def generateMap(width, height):
    """Generate an array that represent a map"""
    #Split the screen into 50px blocks
    toplefts_x = [x for x in range(0, width + 1, 100)]
    toplefts_y = [x for x in range(150, (height + 1) - 150, 100)]
    numX = len(toplefts_x)
    numY = len(toplefts_y)
    #Initialise map array
    Map = []
    #We want to have some buildings here and there
    #But we cannot put them over the tanks
    #Tanks spawn in the top and bottom, y=100 and y=700
    #So we cut out ranges 0>y>150 and height-150 > y > height
    #We now want a small chance for a building to gen, and perhaps a tiny chance of
    possibleBlocks = len(toplefts_x)
    for i in range(possibleBlocks):

```

```

#Random number generator picks the fill for the block
toSpawn = random.randint(0, 60)
#Add a single building
if toSpawn > 50:
    xPos = i % numX
    yPos = i % numY
    Map.append([xPos, yPos, 1])
#Add a 2x2
elif toSpawn == 30:
    xPos = i % numX
    yPos = i % numY
    Map.append([xPos, yPos, 2])

return Map

```

This procedure is pretty well documented, so I'll spare you the line-by-line explanation. I will expand on these lines though:

```

xPos = i % numX
yPos = i % numY

```

These find the x and y block positions from the current iteration in order to allow the client recreate the map after transmission.

3.2.5 Modified Game Rendering Engine

In a fast-paced game, pygame with a livewires wrapper just doesn't cut it; It's not meant for fast rendering and hence I had to make it comply. After digging around the source I found the rendering method. These are the changes I made.

```

while not self._exit:
    self._wait_frame()
    for object in self._objects:
        object._erase()
    self._display.fill(color.white)
    self._display.blit(self._background, (0, 0))
    # Take a copy of the _objects list as it may get changed in place.
    for object in self._objects[:]:
        if object._tickable:
            object._tick()
    self.tick()
    for object in self._objects:
        object._draw()

```

The important lines here are those that reference `self._display`. I modified this engine to fill the screen with colour between ticks to stop the sprites flickering. The first line fills the screen and the second draws the current background on the screen.

3.2.6 Network Communication Method

```

def send(self, message):
    """Send a specified message to the server (pickled)"""

```

```

#Dial the 9th circle of hell and ask for lucifer to process our request
self.toSend = pickle.dumps(message)
try:
    self.sock.sendall(self.toSend)
    self.recieved = pickle.loads(self.sock.recv(2048))
    if self.last != self.recieved:
        self.last = self.recieved
    else:
        self.lastRetries += 1
        if self.lastRetries == 1000:
            raise HostDisconnectedException()
    self.retries = 0
except Exception as e:
    del self.sock
    self.sock = socket.create_connection((self.ip, self.port))
    self.retries += 1
    if self.retries == 5:
        raise HostDisconnectedException()

```

1. Define a new method send that takes argument message
2. Documentation string
3. Nothing to see here, moving on.
4. make a pickle (binary format) object from the specified message.
5. Try to do the following:
6. Send the pickle object over the network
7. Try to decode the server's response which is read as a maximum of 2048 bytes
8. Check if the recieved data is different from the last recieved
9. If it is different, store this new data for furture reference
10. If it isn't different, do the following
11. Increment "retries"
12. After a set number of retries...
13. Timeout.
14. If the data is different, reset retries
15. If there is an error:
16. Delete the connection object
17. Try to reconnect
18. Add 1 to retries
19. If 5 connections fail:
20. Timeout.

3.2.7 Effective Armour Calculations

```

def doesPenetrate(self, angle, bullet):
    """Returns true if the bullet has enough penetration, false otherwise"""
    #This is the critical angle at which any bullet will auto-bounce
    if angle < 50 or angle > 180:
        return False
    #Calculate effective armour via trigonometry.

```

```

    armourValue = self.client.armour
    effectiveArmour = armourValue / math.sin(math.radians(angle))
    #Check if the bullet has enough penetration and return
    if bullet.penetration > effectiveArmour:
        self.damageDone.append([bullet.damage, bullet.ownerId])
        return True
    else:
        return False

```

Again, this function is pretty well commented, but I shall expand.

1. Define a new function, doesPenetrate that takes arguments angle and a bullet object
2. Documentation string
3. Comment
4. Check whether the bullet is at an autobounce angle
5. If it is at autobounce, say that the bullet does not penetrate
6. If it is not autobounce, retrieve the client's armour thickness
7. Find the actual armour thickness at the specified angle
8. Check if the bullet is able to penetrate
9. If it does, put it in an array to let the server know, and say "yes, it penetrates"
10. If not, return false

3.3 Procedure and Variable lists

In this section I will list ever function and variable used throughout my project.

3.3.1 Clientside procedure list

Procedure	Description
Vector.update	Update the vector with new co-ordinates
Vector.useAngle	Create a new vector using a magnitude and angle
Vector.add	Return the resultant vector of this vector added to another
Vector.getMagnitude	Returns the absolute length of the vector
Vector.getDx	Gets the X length of the vector
Vector.getDy	Gets the Y length of the vector
Vector.dotProduct	Returns the scalar product of this and another vector
Vector.collides	Finds whether this vector collides with another
getAngleOfIntersection	Returns the acute angle of vector intersection
getPoints	Returns a list of pixels along a given vector
intersect	Checks whether 2 vectors collide or not
getConfiguration	Reads the config file and returns the option required
Login.createAccount	Asks the login server to add the account
Login.process	Processes the server response
Login.readConfig	Reads the configuration file for ip address and port
Login.send	Send the login credentials to the server
Login.clear	Clear the username/password boxes
Login.doCreate	Start the account creation window
Login.loginComplete	Server has logged us in, proceed to next screen
startLogin	The main method for starting the login GUI
YesNo	Brings up a simple yes or no dialog
Info	Brings up an information box
Warn	Brings up a warning box
netComms.send	Send a specified message to the server (pickled)
netComms.close	Close the active connection
BuyTank.populate	Put the tank names into the list
BuyTank.changeTankPrice	Show the correct price of the selected tank
BuyTank.buyTank	Button press event to send the command to buy the tank
BuyTank.cancel	Close the GUI
UpgradeTank.populateBoxes	Put the selected tank stats into the boxes
UpgradeTank.upHP	Button press event to upgrade HP
UpgradeTank.upDam	Button press event to upgrade damage
UpgradeTank.upArm	Button press event to upgrade armour
UpgradeTank.upPen	Button press event to upgrade penetration
UpgradeTank.upHTr	Button press event to upgrade hull traverse
UpgradeTank.upTTr	Button press event to upgrade turret traverse
UpgradeTank.upRel	Button press event to upgrade reload
UpgradeTank.upSp	Button press event to upgrade speed
UpgradeTank.convertToString	Convert a list of stats into a string
UpgradeTank.getNewStats	Put the upgraded stats into a server-readable format
UpgradeTank.confirmEdit	Ask the user if they are really sure they want to upgrade
UpgradeTank.cancelEdit	Close the GUI without changing anything
UpgradeTank.toInt	Convert a list of floats to ints
SelectATank.battleThread	Set up the client to launch the game engine and then run the game
SelectATank.setHost	Take the user input of the host and store it
SelectATank.getStats	Get the users stats for that specific tank
SelectATank.doStats	Update the text box with the tanks stats

3.3.2 Serverside procedure list

Procedure	Description
getDeltaT	Returns the difference between 2 time.time instances
getPoints	Returns a list of pixels on the line joining (x1,y1) to (x2, y2)
LoginServer.handle	Handle the client request
LoginServer.buy	add a tank to the users account
LoginServer.allXP	Returns the amount of XP the user has earned on each tank
LoginServer.costs	Return the amount that each tank costs
LoginServer.login	Compare the users credentials to the database and login if they match
LoginServer.create	Add a new user to the database
LoginServer.get	Get the stats on the tank requested by the user
LoginServer.convertToString	Self-explanatory, converts a list to a string
LoginServer.createNewAccount	insert all data into the database
LoginServer.xp	Gets the users XP
LoginServer.makeListSane	Make the list how I need it - all strings
LoginServer.openCloseConn	Close and reopen the database connection
LoginServer.update	Update all of the data in the database
LoginServer.owned	Return the tanks owned by the user
start	Start the login server
main	Run game server from another file
superMain	Run game server without checking the login server
generateMap	Generate an array that represent a map
Player.returnValues	Return player values in a list
Player.set	Set all the players data
Bullet.update	Update the bullet based on a time difference
GameServer.ServerUpdatingThread	A thread to keep the server up-to-date
GameServer.finish	End the request process
GameServer.getVictor	Count the players and see who won the game
GameServer.stringRequest	Takes a string and outputs accordingly
GameServer.listRequest	Redirect method for requests in the form of a list
GameServer.isEndOfGame	Looks at all players and decides if the game is over
GameServer.convertToList	This will take Player objects and shove the x,y,angle,turret angle data into a list
GameServer.doHandshake	Add the new player to arrays and get going
GameServer.countdown	Create a 30 second timer at the start of the game
GameServer.convertToListHandshake	Initial return value
GameServer.get	Acts as a 'getter', returns every other player's information and sends it to the client
GameServer.getBuildingRanges	Gets the pixel ranges of the buildings for collision testing
GameServer.isCollidedWithMap	Checks if the bullet is collided with any buildings
GameServer.endgame	Closes the server
ServerSetupForm.stopEvent	In case the user wants to cancel the startup at the last moment
ServerSetupForm.loginThread	A thread to start the login server
ServerSetupForm.getOperatingSystem	Gets the OS of the server machine to bind to IP address
ServerSetupForm.changeInterface	Gets the IP of interface (i.e. wlan, ethernet etc)
ServerSetupForm.startServer	Button press event to start the server
ServerSetupForm.stopServer	Button press event to stop the server
ServerSetupForm.beginTheSatanHailing	Begin to handle requests
ServerSetupForm.watchtheServerIntently	A thread to say if the server should stop
ServerSetupForm.updateTheBulletsThread	A thread that will update all bullets every 0.05 seconds
ServerSetupForm.startServerThread	A thread to handle the server

3.3.3 Client-side Variable list

Variable name	Description	Main Data Type
message	What to send to the server	Pickle object
x	A sprite's x position	int
y	A sprite's y position	int
x1	One end of a vector	int
y1	One end of a vector	int
x2	The other end of a vector	int
y2	The other end of a vector	int
angle	The angle of a vector	float
myVectors	The vectors surrounding an image	List
Parent	The parent window for the GUI	Form
ipAddr	The IP address of the server	string
port	The port of the server	int
conn	The connection to the server	Connection object
toSend	The message to pass to netComms	String
recieved	The response from the server	Pickle object/String
alltanks	Every tank in game	List
xp	The amount of XP on a specific tank	int
owner	Who owns the opened form	Form
hp	The HP of the tank	int
damage	The damage of the tank	int
penetration	The penetration of the tanks gun	int
Reload	The time for the gun to reload	float
Armour	The amount of armour the tank has	int
HullTraverse	How fast the tank turns	float
TurretTraverse	How fast the turret turns	float
Speed	How fast the tank goes	float
owned	The tanks the user owns	list
username	The username of the current player	string
team	The team the user is fighting for	int
userTag	The username floating above the tank	text object
nametag	The tank name floating above the tank	text object
maxHP	The maximum health of the tank	int
state	Is the tank damaged?	int
image	The tank's sprite	image
ownerID	Who fired the bullet?	int
bulletID	Unique ID for the bullet	int
damage	how much damage will the bullet do?	int
ded	Do we update the bullet?	Boolean

3.3.4 Serverside variable list

Variable name	Description	Main Data Type
message	What to send to the client	pickle object
x	The X position of an object	int
y	The Y position of an object	int
name	The name of the user's tank	String
username	The user's username	String
id	The user's ID	int
hp	The HP of the tank	int
isOnWinning	Is the user on the winning team?	Boolean
xpGained	The amount of XP earned from the game	int
damage	The amount of damage done by the user	int
ownerID	The ID of the bullet owner	int
kills	The number of kills by the user	int
angle	The angle of the user's tank	int
turret_angle	The angle of the user's turret	int
ded	Is the bullet "alive"?	boolean
penetration	The level of penetration the bullet has	int
cur	the database cursor	cursor object
data	The data to push to the database	list
newID	The ID of a new user account	int
countdownThread	A thread to keep track of countdown	Thread
opSys	The operating system the server is running on	String
toClose	Shall we close the server?	Boolean

3.4 Annotated Samples of GUI & System Outputs

3.4.1 Tank selection screen

This screen is for selecting a tank and giving server information, it also shows the stats for the currently selected tank. When the "TankBox" is clicked, it will give a list of available tanks. The "Upgrade Tank" and "Buy a tank" open the respective screens.

The screenshot shows a window titled "Armoured Warfare" with standard Windows window controls (minimize, maximize, close). The interface is divided into several sections:

- Select a tank:** A dropdown menu currently displaying "PanzerIV".
- Tank stats:** A scrollable text area containing the following statistics for the selected tank:
 - HP: 400
 - Damage (HP average): 100
 - Penetration (mm): 110
 - Reload (ticks): 200
 - Armour (mm): 40
 - Hull Traverse Speed: 1
 - Turret Traverse Speed:
- Server Address:Port:** A text box containing "localhost:9999".
- Buttons:** At the bottom, there are three buttons: "Roll out!", "Upgrade tank", and "Buy a tank".

3.4.2 Tank upgrade screen

This screen on the clientside allows for the upgrading of tank stats. The text boxes are read-only. If "Upgrade" is clicked on any row, the relevant stat will update, but nothing will be sent to the server until "Confirm" is clicked. If "Cancel" is clicked, the box will close to leave the main tank selection screen.

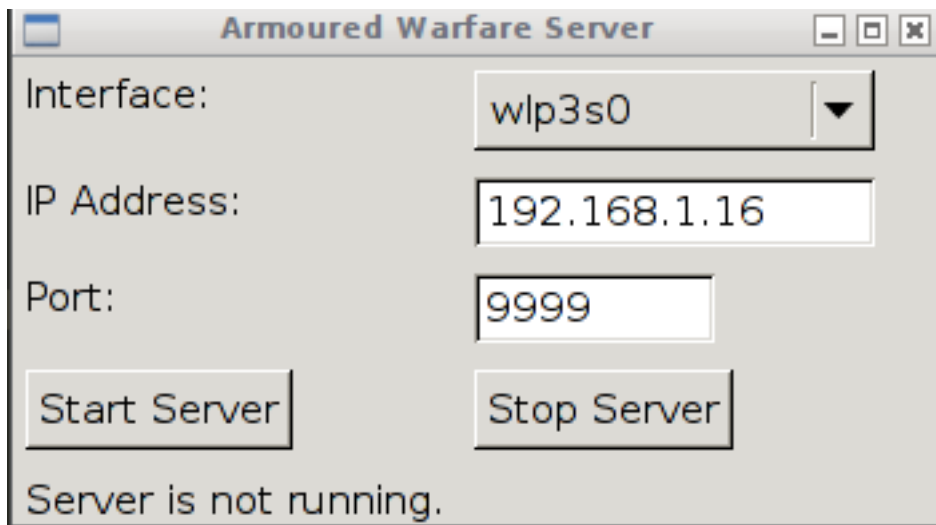
Upgrade A Tank

Upgrading Tank: PanzerIV XP to spend: 990

Hit points:	<input type="text" value="400"/>	<input type="button" value="Upgrade"/>
Damage:	<input type="text" value="100"/>	<input type="button" value="Upgrade"/>
Penetration:	<input type="text" value="110"/>	<input type="button" value="Upgrade"/>
Reload:	<input type="text" value="200"/>	<input type="button" value="Upgrade"/>
Armour:	<input type="text" value="40"/>	<input type="button" value="Upgrade"/>
Hull Traverse:	<input type="text" value="6"/>	<input type="button" value="Upgrade"/>
Turret Traverse:	<input type="text" value="1"/>	<input type="button" value="Upgrade"/>
Speed:	<input type="text" value="1"/>	<input type="button" value="Upgrade"/>

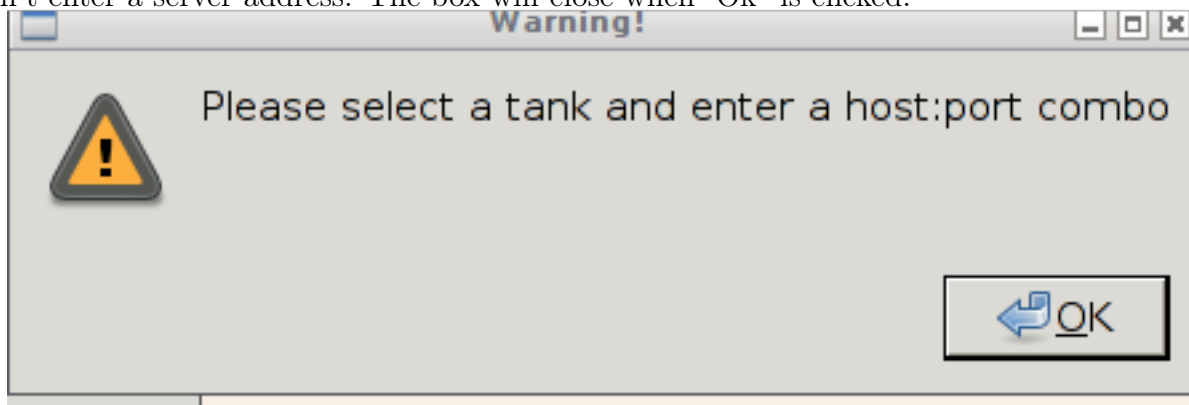
3.4.3 Server setup screen

This screen is on the serverside, it allows for the server operator to select an interface and port on which to run the game server. If the InterfaceBox is clicked, a list of currently attached interfaces (Wlan, Ethernet, etc) appear and the user may pick. The port box allows for any free port to be entered. The server will start when "Start Server is clicked".



3.4.4 General Error Message

This box appears when you attempt to launch the game without either a. Selecting a tank to use or b. Don't enter a server address. The box will close when "Ok" is clicked.



3.4.5 Main Game Screen

This is the main screen of the game. It is controlled using the WASD keys for hull traverse and the arrow keys to traverse the turret. The username and tank name along with the tank HP are displayed above each respective sprite, and the reload timer is situated in the top left of the screen.

Reload in: 38

testaccount
Crusader 300

floatingghost
PanzerIV 325



4 Testing

4.1 Test Data

4.1.1 Login Server Test

Username	Password	Reason for Choice
testaccount	password	Normal Data
testaccount	pasword	Erroneous Data
testaccount	[No data]	Erroneous Data (Incorrect login)
[No data]	password	Erroneous Data (Incorrect login)

4.1.2 Tank Selection Screen

Tank Selection	Reason For Choice
Panzer IV	Normal Data
M4 Sherman	Normal Data
[No selection]	Erroneous Data

4.1.3 Tank Purchase Screen

Tank To Buy	XP to spend	Reason For Choice
Maus	5000	Normal Data
Maus	100	Erroneous Data (Not enough XP)
Maus	300	Boundary Data (Exact price)

4.1.4 Join Game Screen

IP:Port input	Reason for Choice
localhost:9999	Normal Data
localhost:9998	Erroneous Data (no server on port)
[No data]	Erroneous Data
localhost	Erroneous Data (no port)

4.1.5 Bullet Calculations

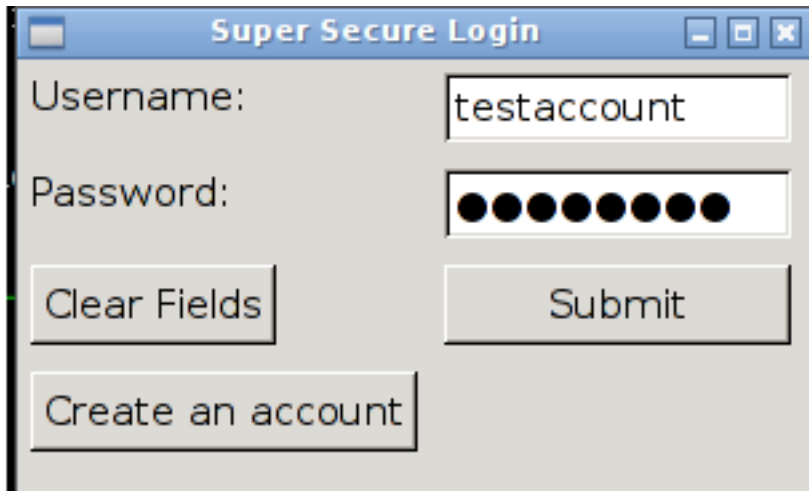
Bullet Angle	Armour Penetration	Armour Thickness	Reason For Choices
90	100	50	Normal Penetration
90	100	100	Boundary Condition
45	100	100	Normal Ricochet
45	150	100	Normal Penetration
10	200000	1	Normal Ricochet

4.2 Test Plan

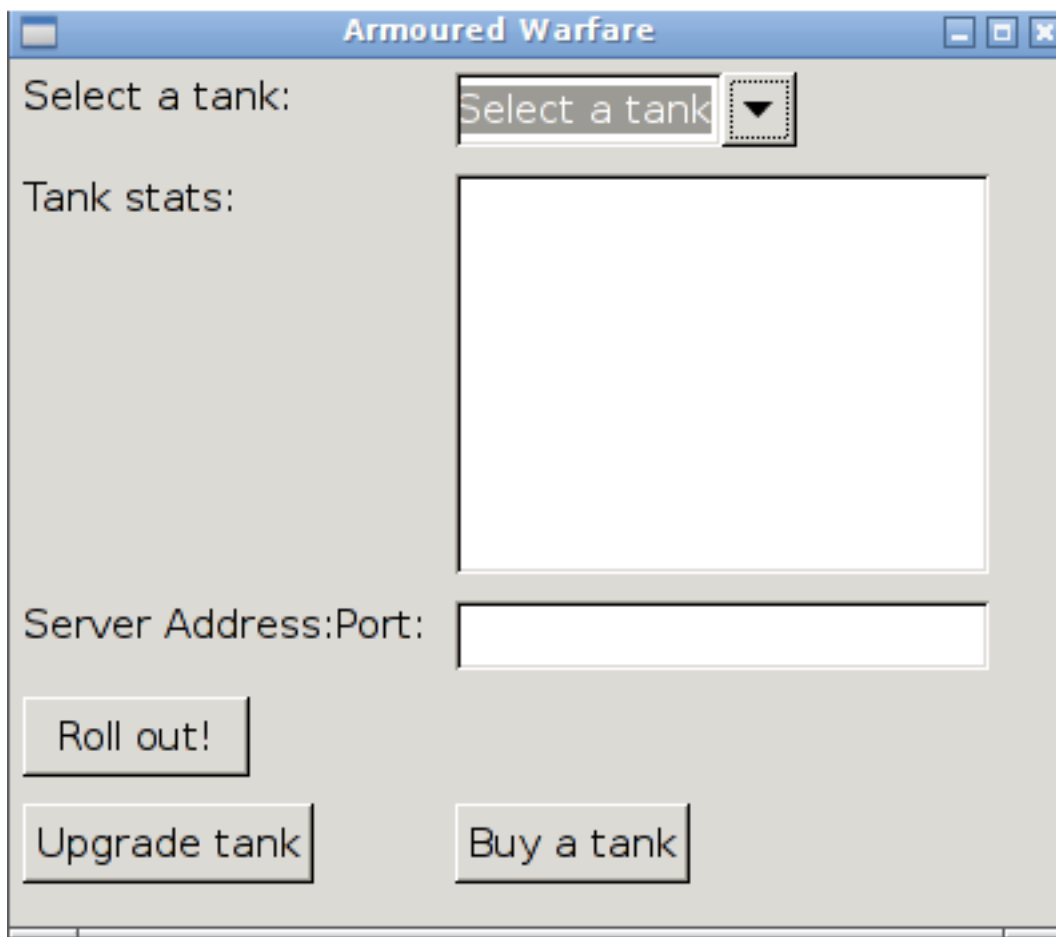
Test	Purpose	Description	Test Data	Expected Result	Pass/Fail
1	Test login server	Give normal data	testaccount/password	“login succesful”	Pass
2	Test login server	Give Incorrect Data	testaccount/password	“login failed”	Pass
3	Test Tank Selection	Select a tank	Panzer IV	Stats appear	Pass
4	Test Tank Selection	No tank selected	[No data]	“Please select a tank”	Pass
5	Test Tank purchase	Have enough XP	Maus/5000XP	“Tank purchased”	Pass
6	Test Tank Purchase	Just enough XP	Maus/300XP	“Tank purchased”	Pass
7	Test Tank Purchase	Not enough XP	Maus/0XP	“You need more XP”	Pass
8	Test Server Connection	Give correct Host/Port	localhost:9999	Connection	Pass
9	Test Server Connection	Give incorrect port	localhost:9998	Error window appears	Fail
10	Test Server Connection	Give no information	[blank]	Error window appears	Pass
11	Test Bullet Calculation	Give penetrating values	100/90/50	Penetration	Pass
12	Test Bullet Calculation	Give boundary condition	100/90/100	Penetration	Fail
13	Test Bullet Calculation	Give angled ricochet	100/45/100	Bounce	Pass
14	Test Bullet Calculation	Give angled penetration	150/45/100	Penetration	Pass
15	Test Bullet Calculation	Give autobounce	20000/10/1	Bounce	Pass

4.3 Evidence

4.3.1 Test 1

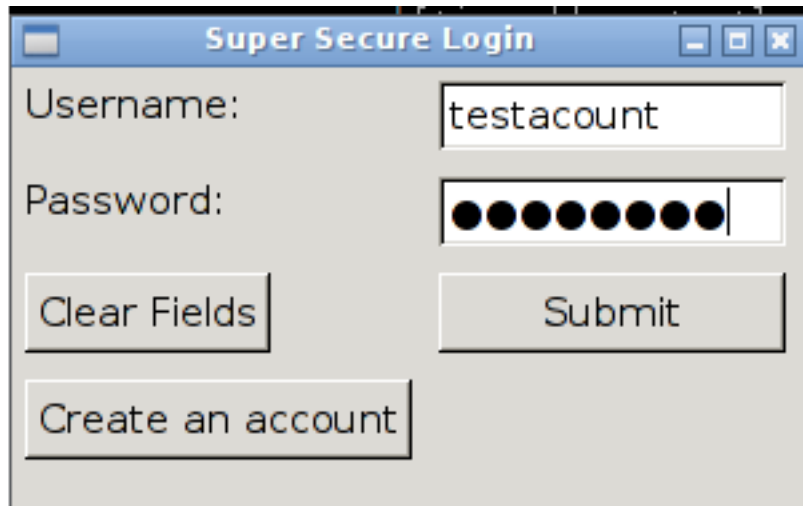


A screenshot of a web application window titled "Super Secure Login". The window has a blue title bar with standard minimize, maximize, and close buttons. The main content area is light gray. It contains two input fields: "Username:" with the text "testaccount" and "Password:" with eight black dots. Below the password field are two buttons: "Clear Fields" and "Submit". At the bottom left, there is a button labeled "Create an account".



A screenshot of a web application window titled "Armoured Warfare". The window has a blue title bar with standard minimize, maximize, and close buttons. The main content area is light gray. It contains a "Select a tank:" label next to a dropdown menu showing "Select a tank" with a downward arrow. Below this is a "Tank stats:" label next to a large, empty rectangular box. Further down is a "Server Address:Port:" label next to an empty text input field. At the bottom, there are three buttons: "Roll out!", "Upgrade tank", and "Buy a tank".

4.3.2 Test 2



A screenshot of a web application window titled "Super Secure Login". It features a username field containing "testaccount" and a password field with ten black dots. Below the fields are three buttons: "Clear Fields", "Submit", and "Create an account".

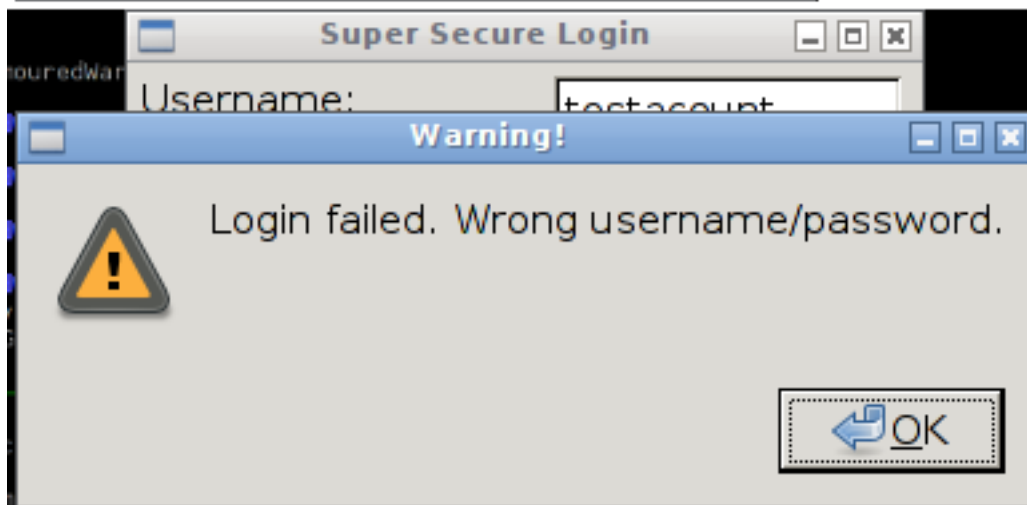
Super Secure Login

Username: testaccount

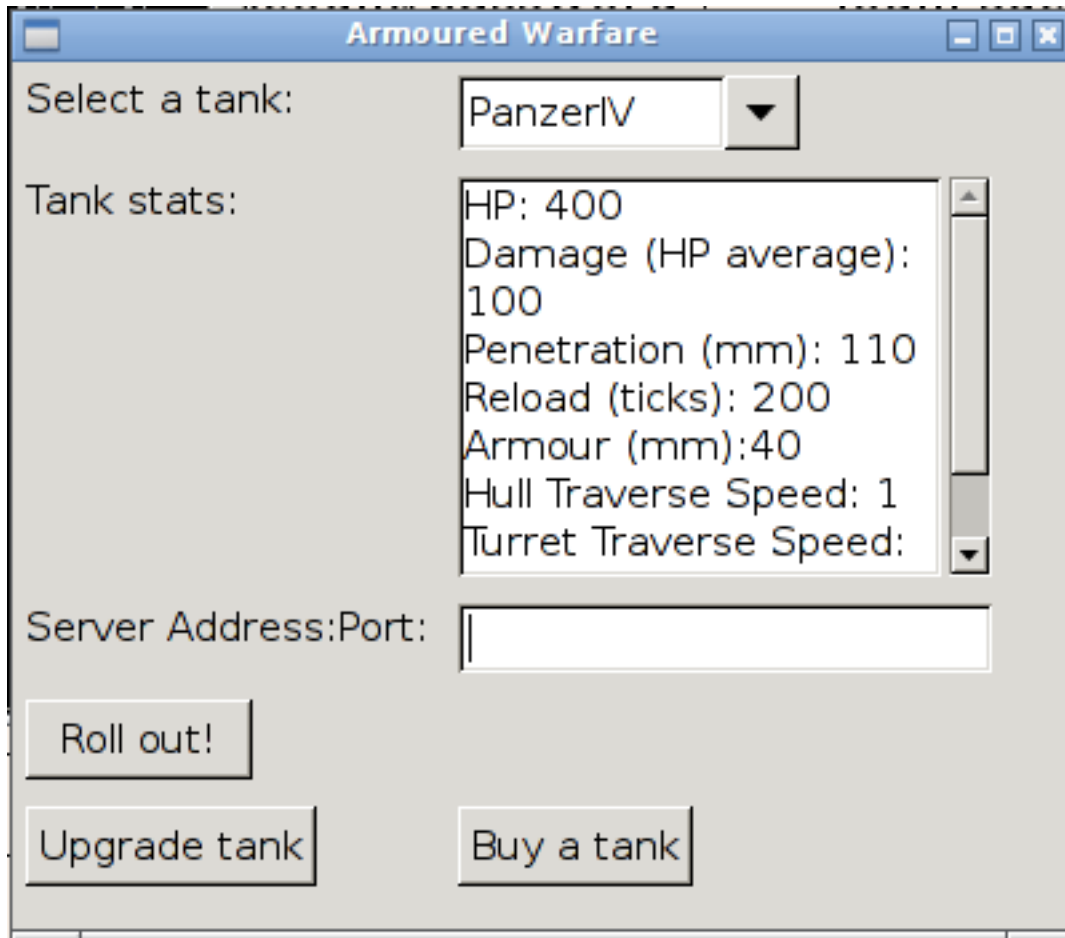
Password: ●●●●●●●●●●

Clear Fields Submit

Create an account



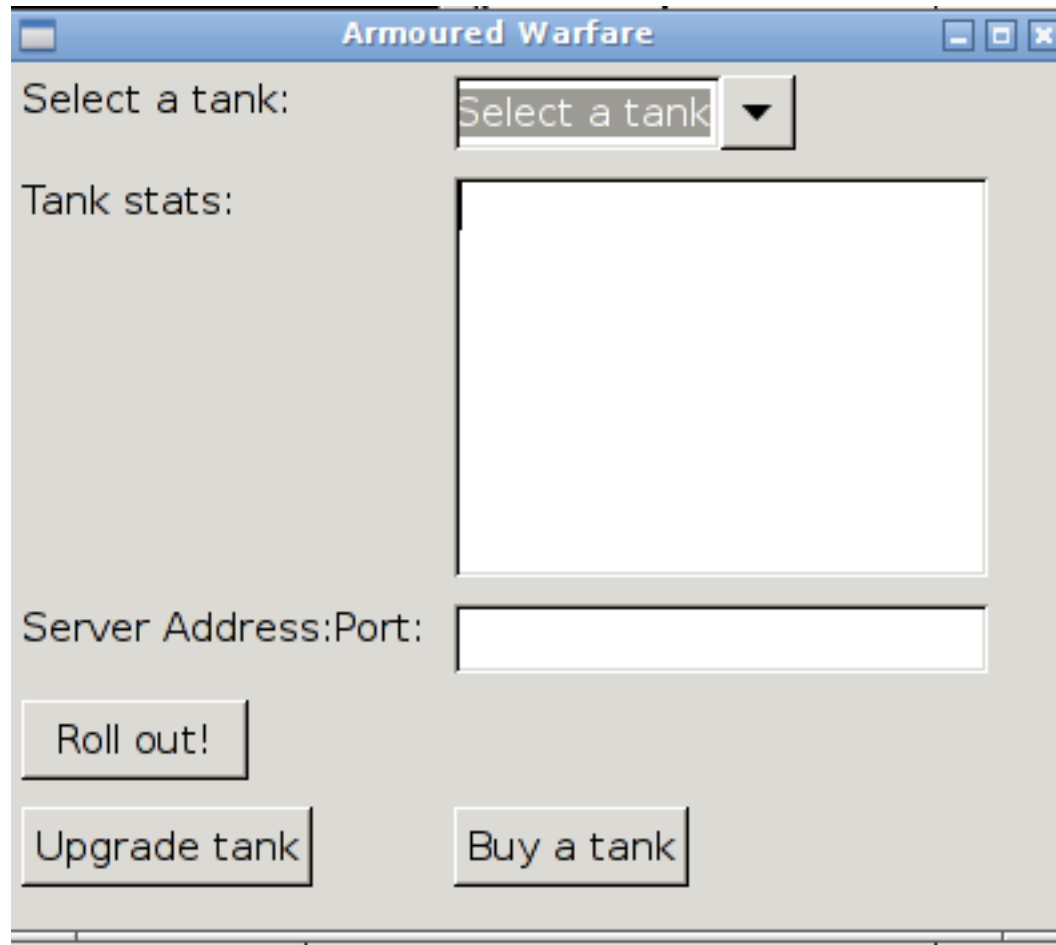
4.3.3 Test 3



The screenshot shows a window titled "Armoured Warfare" with a standard Windows-style title bar (minimize, maximize, close buttons). The window contains the following elements:

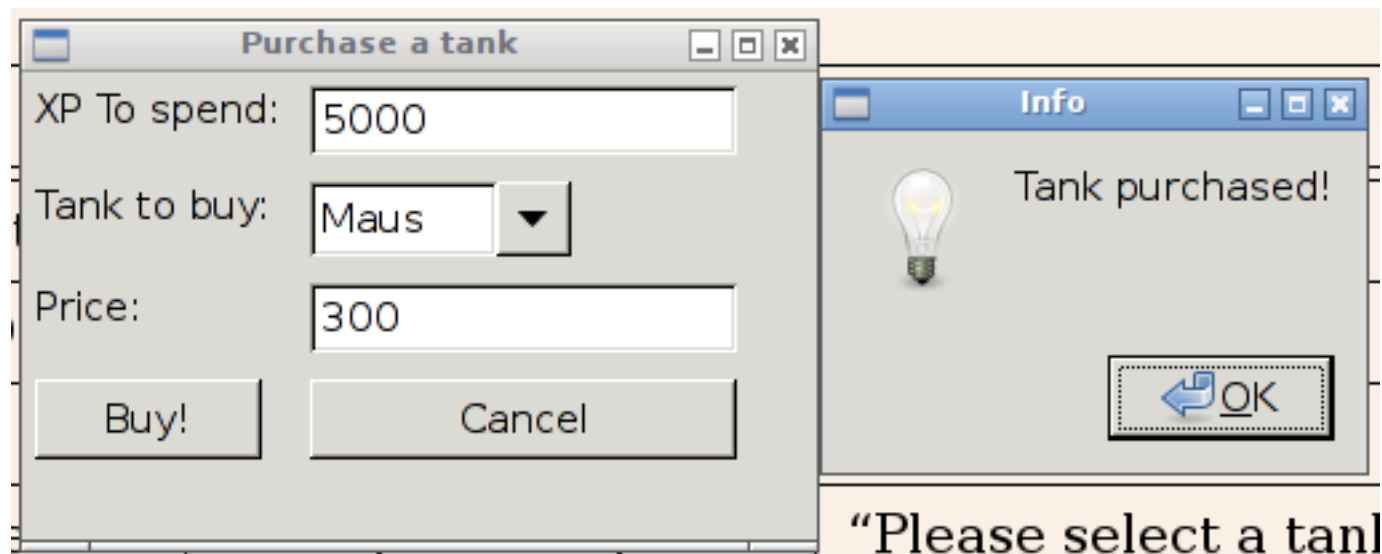
- Select a tank:** A label followed by a text box containing "PanzerIV" and a dropdown arrow button.
- Tank stats:** A label followed by a scrollable text area containing the following statistics:
 - HP: 400
 - Damage (HP average): 100
 - Penetration (mm): 110
 - Reload (ticks): 200
 - Armour (mm): 40
 - Hull Traverse Speed: 1
 - Turret Traverse Speed:
- Server Address:Port:** A label followed by an empty text input field.
- Roll out!** A button.
- Upgrade tank** and **Buy a tank** buttons.

4.3.4 Test 4



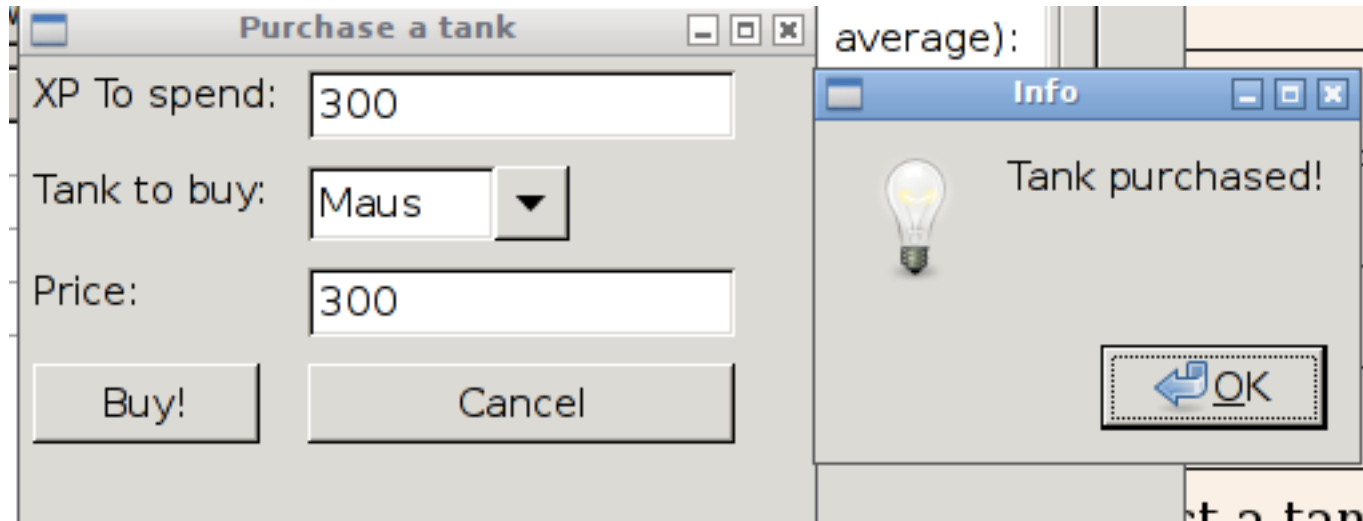
A screenshot of a Windows application window titled "Armoured Warfare". The window has a blue title bar with standard minimize, maximize, and close buttons. The main content area is light gray and contains the following elements: a label "Select a tank:" followed by a dropdown menu with "Select a tank" and a downward arrow; a label "Tank stats:" followed by a large empty rectangular box; a label "Server Address:Port:" followed by an empty text input field; a "Roll out!" button; an "Upgrade tank" button; and a "Buy a tank" button.

4.3.5 Test 5

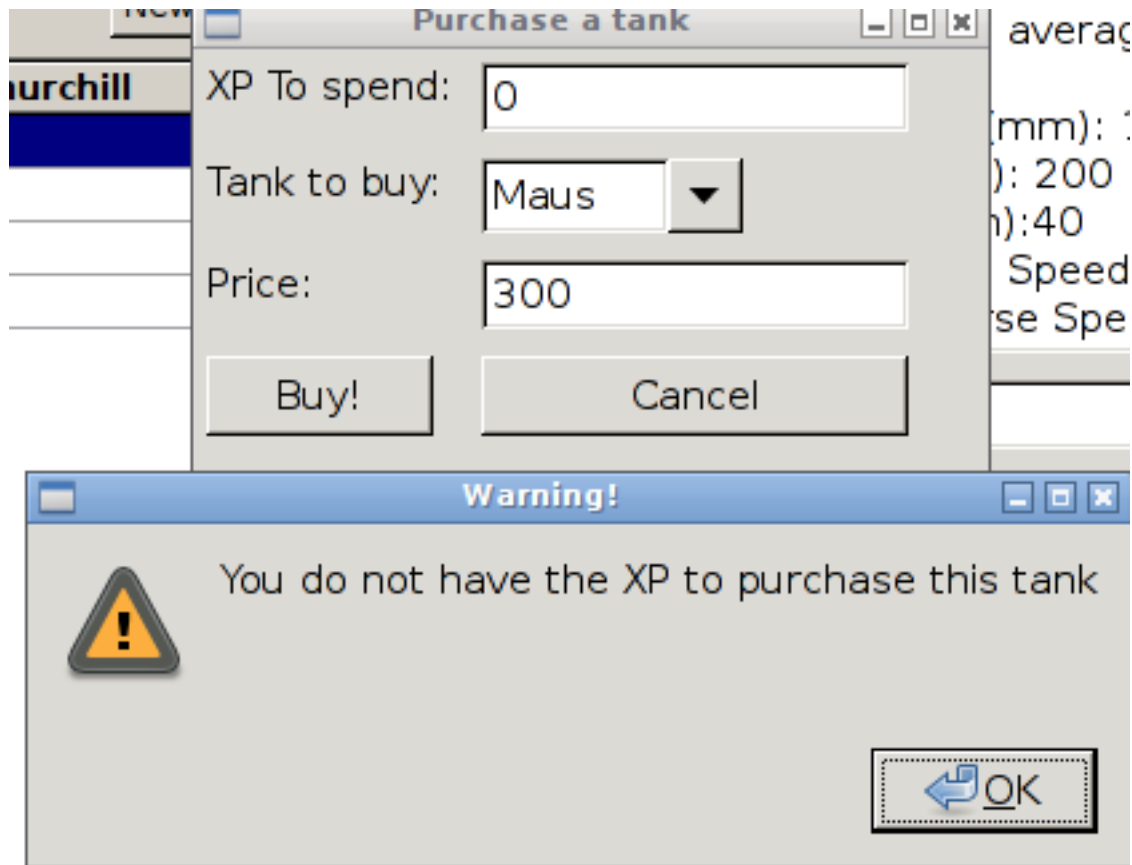


A screenshot showing two overlapping Windows application windows. The foreground window is titled "Purchase a tank" and contains: a label "XP To spend:" with a text input field containing "5000"; a label "Tank to buy:" with a dropdown menu showing "Maus"; a label "Price:" with a text input field containing "300"; a "Buy!" button; and a "Cancel" button. The background window is titled "Info" and contains: a lightbulb icon; the text "Tank purchased!"; and an "OK" button with a blue arrow icon. Below the "Info" window, the text "Please select a tank" is visible.

4.3.6 Test 6

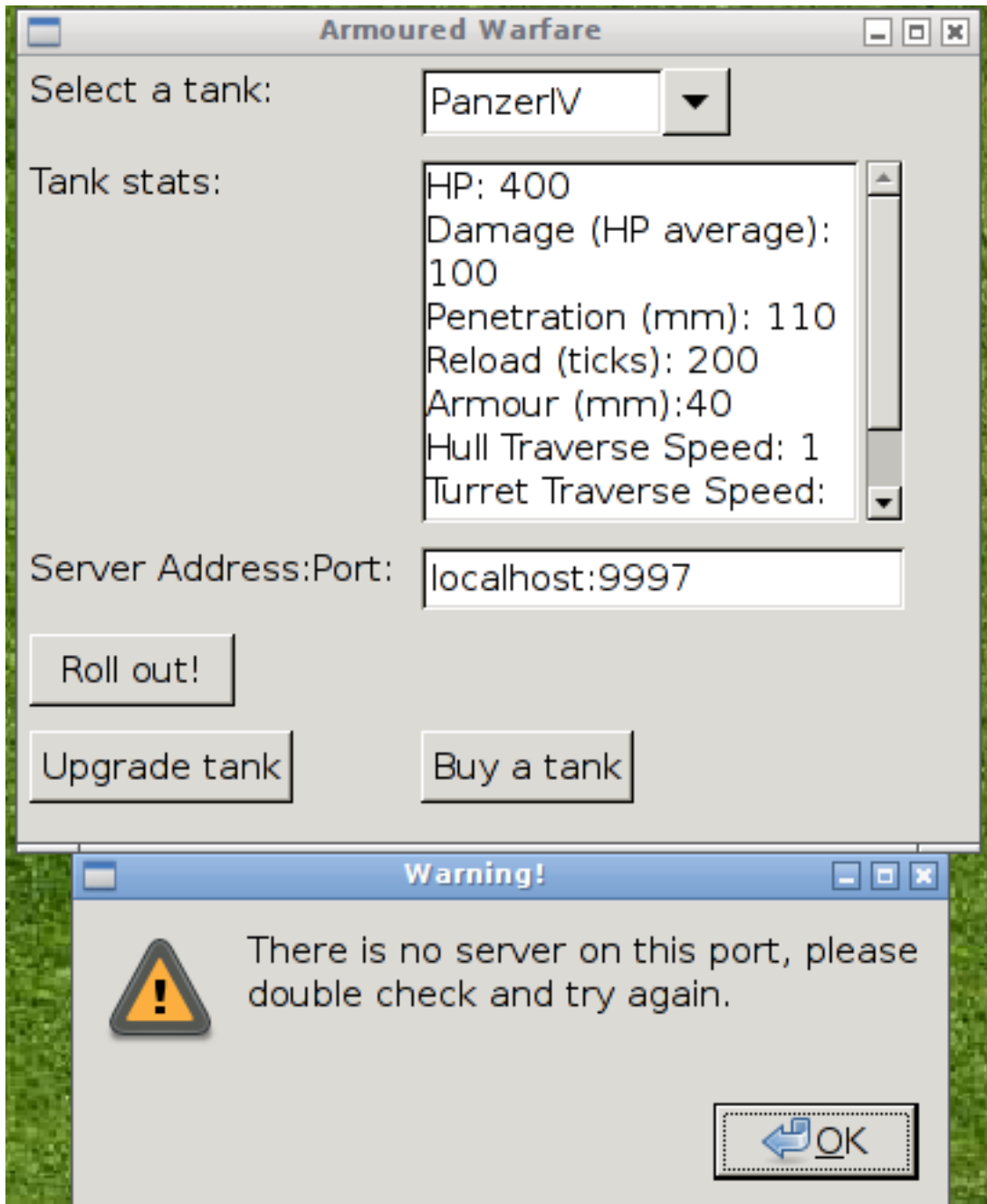


4.3.7 Test 7





4.3.9 Test 9



4.3.10 Test 10

The screenshot shows a window titled "Armoured Warfare" with a grey background. It features a "Select a tank:" label next to a dropdown menu currently showing "PanzerIV". Below this is a "Tank stats:" label next to a scrollable text area containing the following statistics: HP: 400, Damage (HP average): 100, Penetration (mm): 110, Reload (ticks): 200, Armour (mm): 40, Hull Traverse Speed: 1, and Turret Traverse Speed: . At the bottom of the window are three buttons: "Roll out!", "Upgrade tank", and "Buy a tank". A "Server Address:Port:" label is positioned above an empty text input field. Overlaid on the bottom of the window is a "Warning!" dialog box with a blue title bar. It contains a yellow warning triangle icon and the text "Please select a tank and enter a host:port combo". An "OK" button with a blue arrow icon is located at the bottom right of the dialog box.

Armoured Warfare

Select a tank: PanzerIV ▼

Tank stats:

- HP: 400
- Damage (HP average): 100
- Penetration (mm): 110
- Reload (ticks): 200
- Armour (mm): 40
- Hull Traverse Speed: 1
- Turret Traverse Speed: .

Server Address:Port:

Roll out!

Upgrade tank Buy a tank

Warning!

⚠ Please select a tank and enter a host:port combo

⬅ OK

4.3.11 Tests 11-15

```
~/ArmouredWarfareSimulator/Client(branch:master*) » python clientTests.py
test_penetration (__main__.MyTestCase) ...
Testing 100 pen at 90 degrees against 50mm of armour
Testing 100 pen at 90 degrees against 100mm of armour
Testing 100 pen at 45 degrees against 100mm of armour
Testing 150 pen at 45 degrees against 100mm of armour
Testing 20000 pen at 10 degrees against 1mm of armour
ok
-----
Ran 1 test in 1.003s

OK
```

4.4 Error Log

4.4.1 Incorrect port given

```
Error whilst init netcomms: [Errno 111] Connection refused
Traceback (most recent call last):
  File "/home/harry/ArmouredWarfareSimulator/Client/SelectATank.py", line
n goToBattle
    a = self.battleThread(instance)
  File "/home/harry/ArmouredWarfareSimulator/Client/SelectATank.py", line
n battleThread
    a = TankClient.mainGame(instance)
  File "/home/harry/ArmouredWarfareSimulator/Client/TankClient.py", line
mainGame
    fat_controller = GameController(stats, host, port, username)
  File "/home/harry/ArmouredWarfareSimulator/Client/TankClient.py", line
__init__
    self.setupGame(stats, host, port, username)
  File "/home/harry/ArmouredWarfareSimulator/Client/TankClient.py", line
setupGame
    self.connection = netComms.networkComms(host, int(port))
  File "/home/harry/ArmouredWarfareSimulator/Client/netComms.py", line 16
init__
    raise NoConnectionException()
Errors.NoConnectionException
^C
```

This screenshot is the python output if you try and connect where there is no server.

This was an easy one to fix. I simply appended this to the game launch method:

```
except NoConnectionException:
    messages.Warn(self.parent, "There is no server on this port, please double
self.Show(True)
```

It works just fine.

4.4.2 Penetration Boundary Condition

```
~/ArmouredWarfareSimulator/Client(branch:master*) » python clientTests.py
test_penetration (__main__.MyTestCase) ...
Testing 100 pen at 90 degrees against 50mm of armour

Testing 100 pen at 90 degrees against 100mm of armour
FAIL

=====
FAIL: test_penetration (__main__.MyTestCase)
-----
Traceback (most recent call last):
```

Simple change of boolean conditions here.

In Client/TankClient.py, line 744 was the culprit.

```
if bullet.penetration > effectiveArmour:
```

was changed to become

```
if bullet.penetration >= effectiveArmour:
```

References

- [1] NPD Group study into PC Usage: URL: <https://www.npd.com/wps/portal/npd/us/news/press-releases/the-npd-group-report-shows-increased-number-of-online-gamers-and-hours-spent-gaming/>
- [2] Slick Muffin Studios URL: <http://slickmuffin.weebly.com/>