Tower Defense

By

Ryan Wauligman

Design Freeze Submitted to
the Faculty of the Information Engineering Technology Program
in Partial Fulfillment of the Requirements for
the Degree of Bachelor of Science
in Information Engineering Technology

University of Cincinnati
College of Applied Science

May 2009

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Ryan Wauligman	Date
Dr. Hazem Said, Faculty Advisor	Date
Dr. Hazem Said, Department Head	Date

Acknowledgements

I want to thank everyone who helped me with my project. A special thanks to Dr. Said for being my advisor, thanks for helping me stay focused and challenging me. Thanks to the XNA Community for your tutorials and videos, they were extremely helpful. I would also like to thank Dustin Schleibaum for his help with the graphics and testing. Thanks to my family and friends who have supported me, thanks for keeping me sane throughout this project. Thanks again everybody!

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Abstract

Tower Defense is a game of skill for the Xbox 360. It was created with XNA Game studio in Microsoft C# 2008 Express Edition. *Tower Defense* is an arcade style strategy game in which the player must construct towers in a strategic order to eliminate the waves of monsters trying to make their way across the map. The player earns money and points for each monster destroyed, but if a monster makes it across the map the player loses a life point. If the player loses all life points, the game ends. Spend your money to build more advanced towers or upgrade existing towers. Just be sure to watch the clock as waves of monsters spawn at fixed times, even if monsters are still on the field.

Tower Defense

1. Product Description and Intended Use

The "Tower Defense" game is a strategy game in which the player creates a maze that monsters have to walk through to reach their destination on the opposite side of the game map. The player creates the maze with different projectile-firing towers which all have different strengths and weaknesses; some towers may have a longer attack distance and others may slow the monsters they attack, for example. To increase the challenge, there are several types of monsters as well; some move faster, some take reduced damage, and some heal. The game will be available for download on the Xbox 360 console. It is being created in Microsoft Visual C# using the XNA Framework. The XNA Framework is required for developing games for the Xbox 360.

The game concept has already changed since Senior Design I. It was originally planned as a hack and slash game, but the graphics were too demanding, so with my advisor's permission, we changed the game to a type which requires fewer graphics.

"Tower Defense", the game's tentative title, after going through Microsoft's strict certificate process will then be available on the Xbox 360 Community Marketplace, where thousands of people from around the world can download and play this game. Most games currently on the marketplace are arcade style games, like Pacman or Galaga. These games are all similar in that the player can jump in and play the game all the way through in around an hour; so "Tower Defense" will need to be similar while still providing a much needed challenge. This can be tricky, to balance difficulty while still being accessible enough to let anyone play. To achieve this, the monsters will need to spawn in small groups, but as time passes the difficulty increases, and the groups will get larger. If there are 100 consecutive waves and they occur every 30 seconds at most, the game would last around 50 minutes. Each wave will need to be more challenging than the last. This has been achieved by increasing the monsters' attributes and increasing the group size.

1.1 User Profiles

Users do not need any special IT literacy to play this game. They will, however, need all of the required hardware and software. They will need the Xbox 360, TV and an Internet Connection so that they can download the game from the Xbox Community Marketplace. Once the game is downloaded to their Xbox 360, the Internet connection will no longer be needed, allowing the players to take this game wherever they can take their Xbox 360.

2. Design Protocols

2.1 Interface Design

There are four objects on the interface, as can be seen in Figure 1. The smallest box in the top left corner is the "Selected Box." This box shows a small image of what is currently selected. For example, if the player selects a tower, the "Selected Box" will show the details about that tower. To the right of the "Selected Box" is the "Status Bar." The "Status Bar" shows the player's score, the clock, which wave of monsters the player is on, how many life points the player has, and how much money the player has earned. Below the "Status Bar" is the "Game Map." This is where the player builds towers to stop the monsters from making it across the map. To the left of the game map is the

“Tower Toolbar.” This box holds the “Tower Toolbar,” which has all of the towers that the player can build. See Figure 1 below for details.

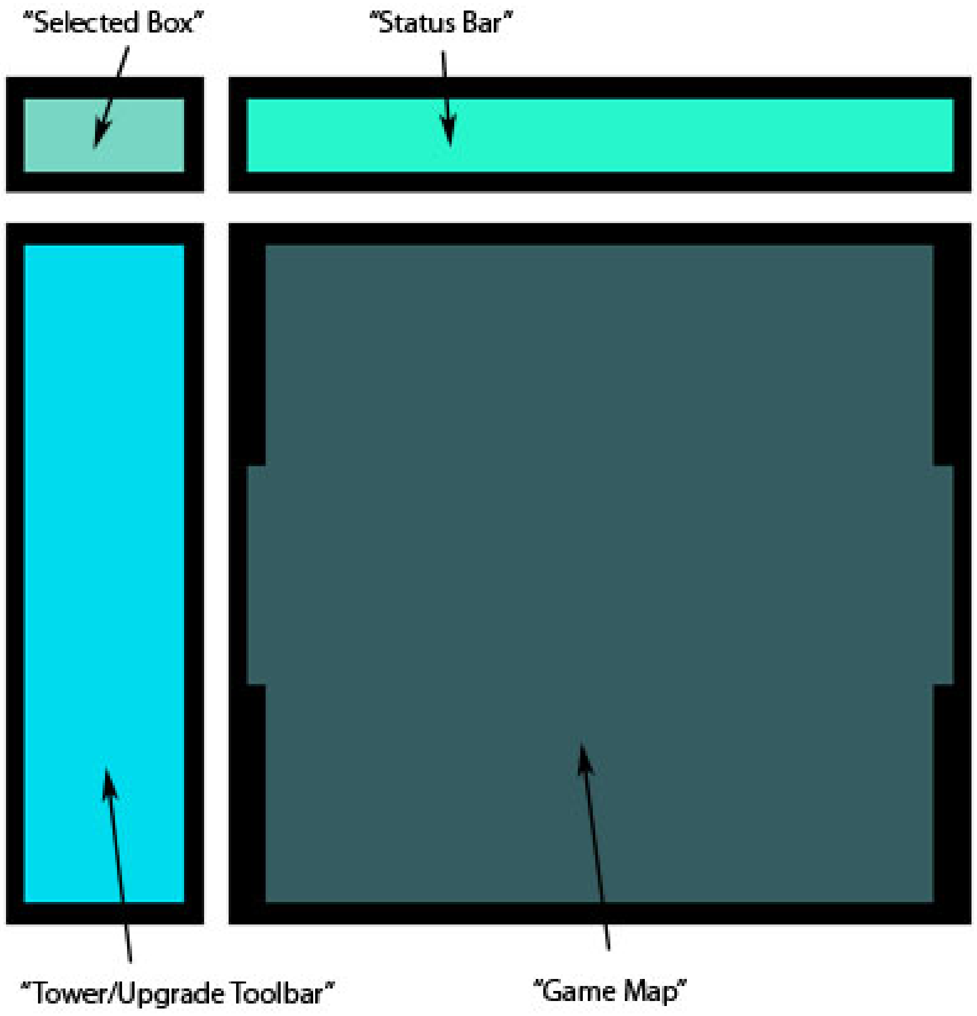


Figure 1: Game Map

2.2 Controls

2.2.1 Start Menu

The “Start Menu” appears once the player runs the game. From here the player has four options which can be seen in Figure 2 below. They can “Start a New Game,” “View High Scores,” “View Help,” and “Exit Game.” If a new game is selected, the “Game Menu” will replace the “Start Menu.” If “View High Scores” is selected, it will show the “High Scores Page.” If “View Help” is selected, the “Game Help” page replaces the start menu. Finally, if “Exit Game” is selected, it will return the player to the Xbox 360 Dashboard. This is shown in Figure 2 below.

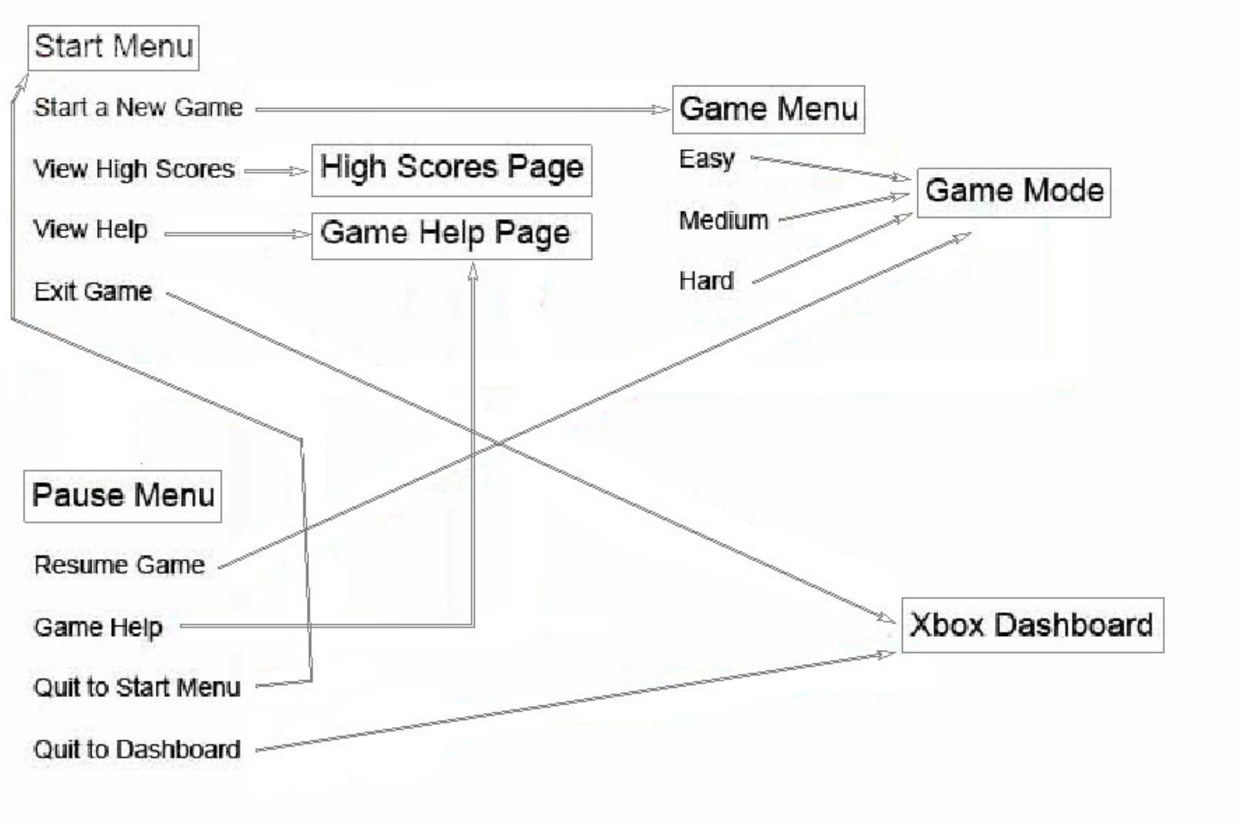


Figure 2: Menu Diagram

2.2.2 Game Menu

The “Game Menu” shows the games available to play; players can select “Easy,” “Medium,” “Hard,” and “Back to Start Menu.” If the player selects “Back to Start Menu,” the “Start Menu” replaces the “Game Menu.” If they select any of the other options, the controls will shift to “Game Mode” in the selected difficulty.

2.2.3 Game Mode

The game controls are quite simple. The left joystick moves the reticule around the interface. The “A” button selects whatever the reticule is above. If the player selects a tower in the “Tower Toolbar,” the “Selected Box” will show the tower the player has selected, which indicates that the player is in “Tower Building Mode.” When in “Tower Building Mode,” if the user moves the reticule over the “Game Map,” a box will appear under the reticule; the box indicates the location the tower would be built at on the “Game Map.” If the box is green, then the player can build a tower by pressing the “X” button; if the box is red, the tower can’t be built there. The player can exit out of “Tower Building Mode” by pressing the “B” button. If the player reticule’s over a tower on the “Game Map,” they can select it by pressing the “A” button. This enters “Upgrade Mode;” in “Upgrade Mode,” the tower details will show up in the “Selected Box”. The player can upgrade the tower by pressing the “X” button. The player can exit “Upgrade Mode” by pressing the “B” button. The player can also select monsters on the “Game Map” by moving the reticule over them and pressing the “A” button. When the player selects a monster, the monster’s details will show up in the “Selection Box.” The “Start” button will pause the game and open the “Pause Menu,” where the player can exit the game if desired. See Figure 3 below for details.

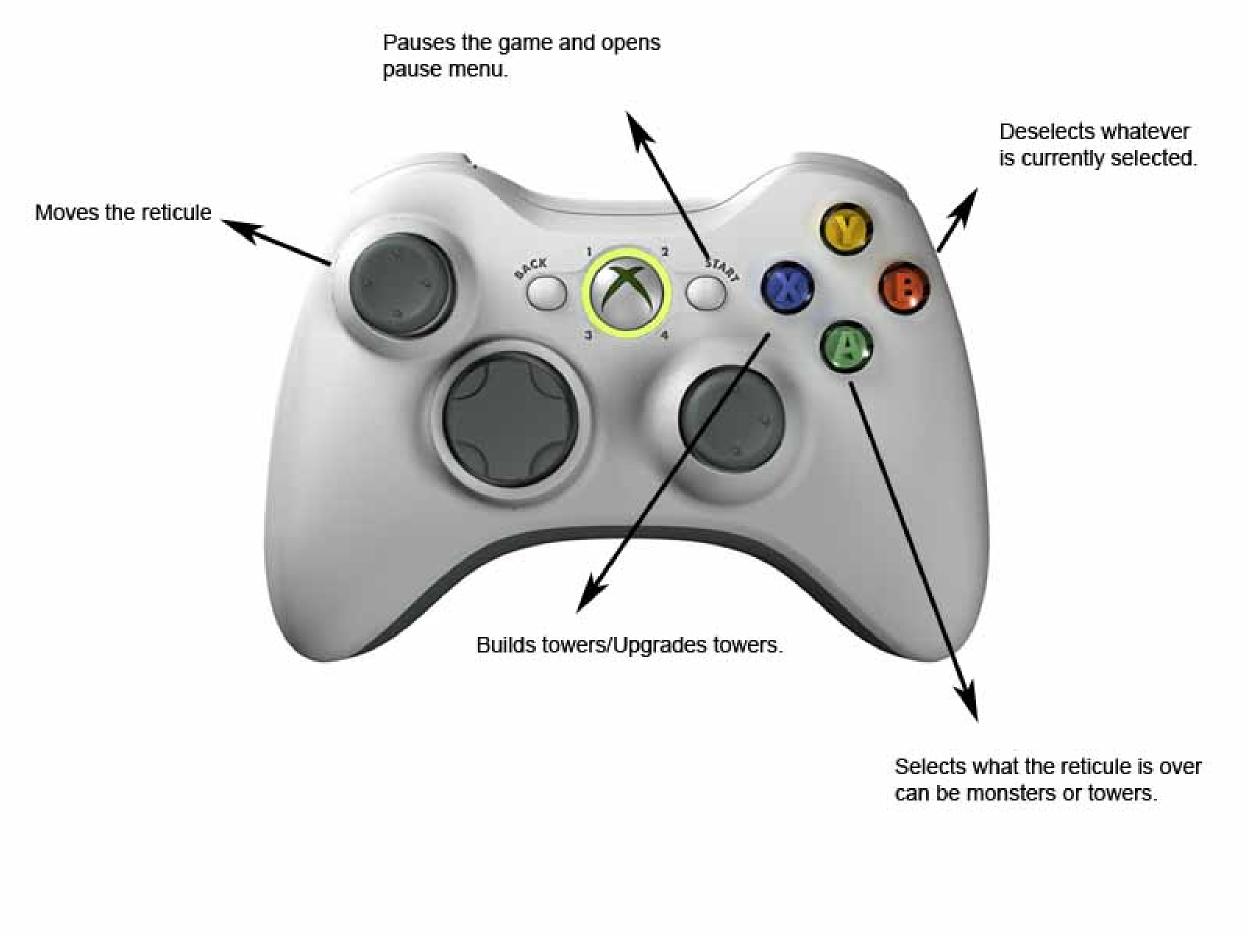

Pauses the game and opens pause menu.
Deselects whatever is currently selected.
Moves the reticule
BACK
START
1
2
3
4
Y
X
B
A
Builds towers/Upgrades towers.
Selects what the reticule is over can be monsters or towers.

Figure 3: Game Controls

2.2.4 Pause Menu

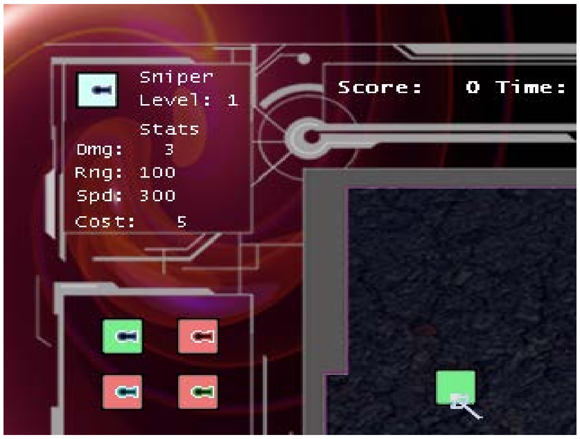
The “Pause Menu” has four options; “Resume Game,” “Game Help,” “Quit to Start Menu,” and “Quit to Dashboard”. “Resume Game” returns the player to “Game Mode”, “Quit to Start Menu” returns the player to the “Start Mode” and “Quit to Dashboard” returns the user to the Xbox Dashboard.

2.2.5 Game Help

The “Game Help” shows the game controls and instructions on how the game is played. The player can exit “Game Help” by pressing the “B” button, which will return the player to the previous menu (Pause Menu or Start Menu).

2.3 Icons/Graphical Symbols

The tower and monster graphics are important symbols. The “Selection Box” indicates what the player currently has selected by showing the graphic as well as its details.



Sniper
Level: 1
Stats
Dmg: 3
Rng: 100
Spd: 300
Cost: 5

Score: 0 Time:

Figure 4: An in game screenshot showing the details of the selected tower.

2.4 Game Play

The game will be played on the Xbox 360 game console. Once the player downloads the game it will show up in their “Community Games” menu. Once he launches the game, it will take the player to the “Game Menu”. From there the player can move through menu system as described in the “Controls” portion of this document. Once he launches a game, it will take him to the game map. The game starts in a paused state, the player will then have their only opportunity to build towers in pause mode with their starting money. The game will start when the player presses the start button on the screen. At that time monsters will spawn in groups every 30 seconds. The player's objective is to destroy the monsters before they reach the opposing side of the game map. They will, therefore, need to build towers in strategic locations on the map to maximize the damage they will do to monsters. As the player's towers destroy the monsters, the player will accumulate points for the player's score as well as earn money which can be used to build or upgrade towers. If a monster makes it completely across the game map, the player loses a life point. The game will end if the player loses all of their life points or if they make it through every wave of monsters.

2.5 Game Specifics

2.5.1 Towers – Towers all have the same attributes listed below but with a unique combination. The tower attribute values may change during testing.

Tower Attribute Descriptions

- **Cost** – How much it costs to build the tower.
- **Range –** How far the tower can shoot.
- **Damage –** How much damage the tower deals to monsters.
- **Attack Speed –** How fast the tower attacks.
- **Special –** The tower's unique special ability.
- **Weakness –** The tower's unique weakness.

2.5.1.1 Sniper Tower

- **Cost** – High
- **Range** – High
- **Damage –** Moderate
- **Attack Speed** – Slow
- **Special –** *Critical Hit* – Each tower attack will have a chance to multiply damage.

2.5.1.2 Machine Gun Tower

- **Cost** – Medium
- **Range** – Moderate
- **Damage –** Moderate
- **Attack Speed** – Fast
- **Special –** *Armor Piercing rounds –* Damage goes through armor.
- **Weakness –** *Weapon Jams –* Each attack has a chance to fail.

2.5.1.3 Fire Tower

- **Cost** – Medium
- **Range** – Low
- **Damage** – Moderate AOE
- **Attack Speed** – Slow
- **Special –** *AOE Damage* – Damage hits multiple targets.

2.5.1.4 Plasma Tower

- **Cost** – Low
- **Range** – Low
- **Damage** – Low
- **Attack Speed** – Moderate
- **Special –** *Cold Damage* – Slows the monsters movement speed.

2.5.2 Tower Upgrades – Tower attributes can be upgraded to make more case specific towers, but each tower can only have a certain number of upgrades. Upgrades may change during the balance testing.

Upgrade Range - Increases the towers shooting distance.
Upgrade Damage - Upgrades the amount of damage the tower does.
Upgrade Splash - Allows the tower to hit multiple monsters.
Upgrade Special - Increases the towers special ability.

2.5.3 Monsters – Monsters share the same list of attributes but have unique values. The attributes are listed below. The monster attribute values may change during balance testing.

Monster Attribute Descriptions

- **Health** - Amount of damage the monster can take before dying.
- **Speed** - How fast the monster moves.
- **Armor** - Number of damage negated.
- **Resistance** - Percentage of damage resisted.

2.5.3.1 Normal

- **Health** - Normal
- **Speed** - Normal
- **Armor** - None
- **Resistance** - None

2.5.3.2 Fast

- **Health** - Normal
- **Speed** - Fast
- **Armor** - None
- **Resistance** - None

2.5.3.3 Resisters

- **Health** - Normal
- **Speed** - Normal/Slow
- **Armor** - None
- **Resistance** - High

2.5.3.4 Tanks

- **Health** - Medium/High
- **Speed** - Normal/Slow
- **Armor** - Medium
- **Resistance –** Low

2.5.3.4 Boss

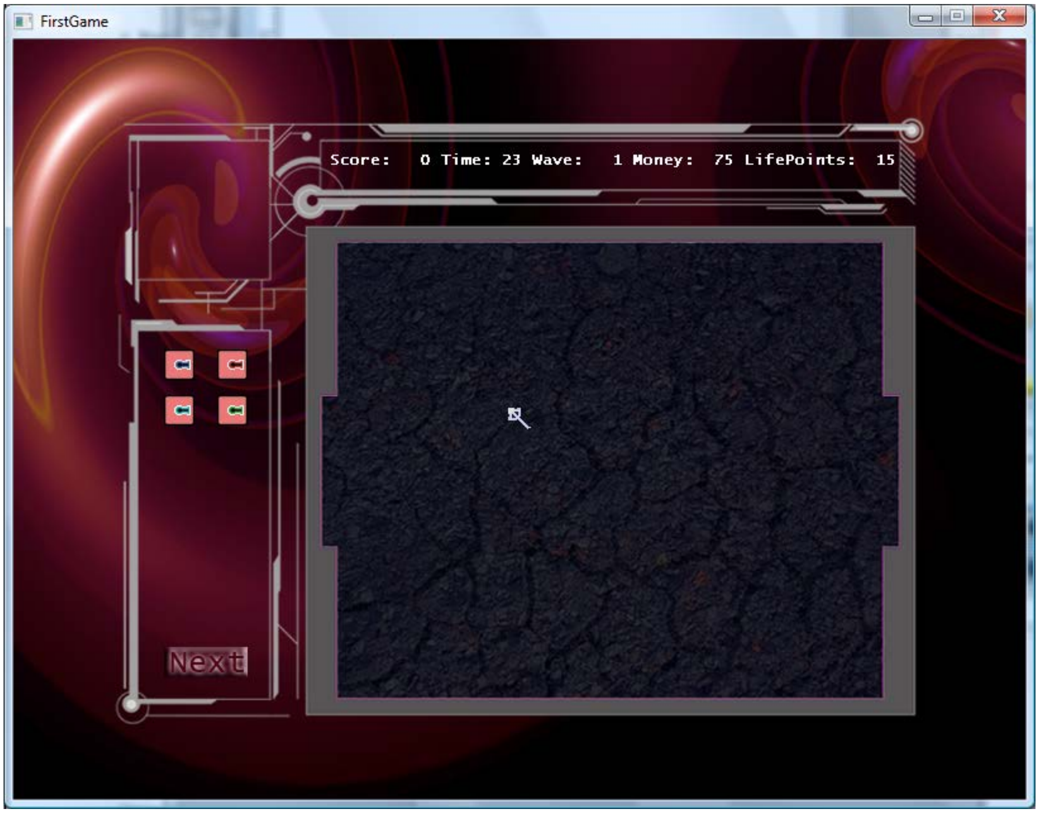
- **Health** - High
- **Speed** - Fast
- **Armor** - Medium
- **Resistance** - Medium

3. Deliverables

I will be delivering a game as described in the Design Protocols portion of this document.

4. Proof of Concept

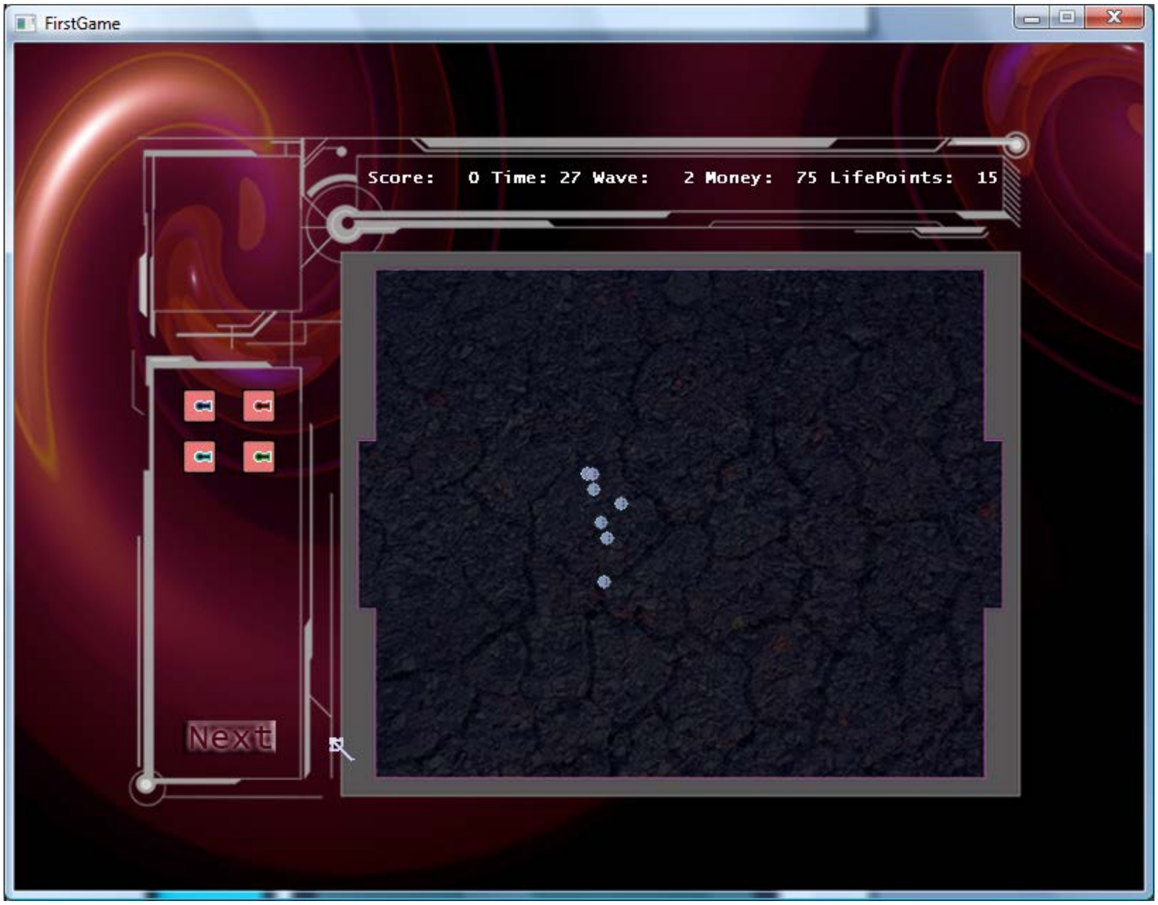
The proof of concept demonstrates all the functionality that a tower defense game needs. Near the beginning of the winter semester we agreed that I would need to demonstrate how the monsters and towers will interact on the game map. Below in Figure 4 is a screenshot taken of the game map when the game starts. The player has just arrived in “Game Mode”. Because the game has just started, there isn’t much going on. You can see in the “Status Box” that the player has a score of 0, there are 23 seconds remaining until the first wave of monsters. The player has 75 points to spend on towers and has all 15 of there LifePoints. Below the “Selection Box” on the “Game Map” you can see the reticule, which is the white want near the center of the “Game Map”. To the left of the “Game Map” you can see the four different towers in the “Tower Toolbar”.



Score: 0 Time: 23 Wave: 1 Money: 75 LifePoints: 15

Figure 5: Screenshot of the game board.

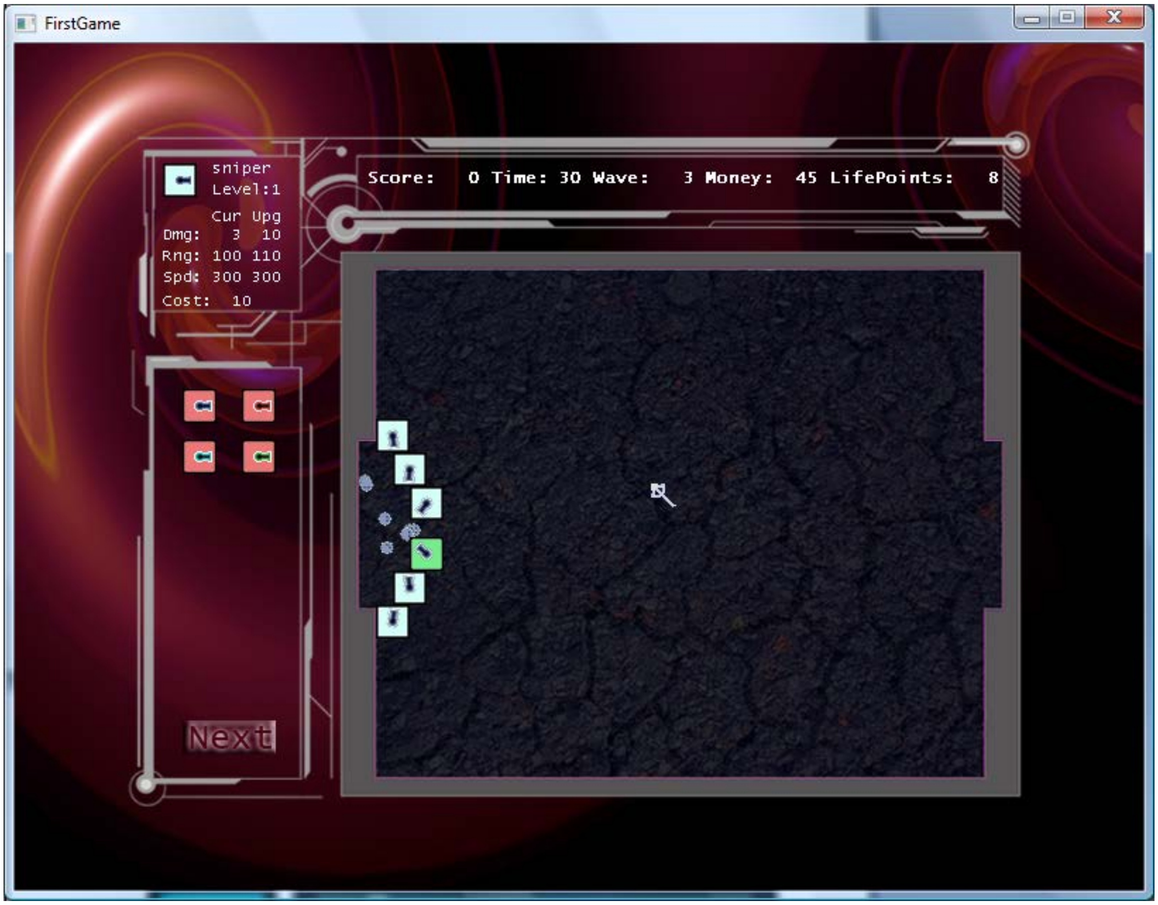
A few seconds after the Game starts, monsters spawn and begin moving across the screen. The screenshot below (Figure 5) was taken a few moments after the previous one. Since then four Monsters have spawned on the left side of the "Game Map" and are making their way across to their destination on the right side of the "Game Map". The monsters below are the standard monsters in the game. These monsters move at normal speed, have an average number of health points, and have no special properties. Because there are no towers, these monsters have no problem making their way across the game map. If the game was fully functional the player would lose a life point as each monster makes it out of the game map.



```
Score:    0 Time: 27 Wave:    2 Money:   75 LifePoints:   15
```

Figure 6: Screenshot showing monsters moving at the beginning of the game.

The following screenshot (Figure 6) was taken during the next wave of monsters. Because the player didn’t build any towers during the first round, all of the monsters in the first wave made it across, and the player lost some of their LifePoints. The player has since built six towers near the monster entrance on the game map. These towers are firing at the monsters but haven’t killed any. The towers were also built in the way of the monsters so the monsters had to move slightly to make their way around. However, the monsters don’t have much trouble getting around them, and they will all make it across, which will cause the player to lose additional life points. The towers featured in this screenshot are the “Sniper Towers”, but they are not upgraded, so they don’t have any special properties. They fire moderately slow and do normal damage.

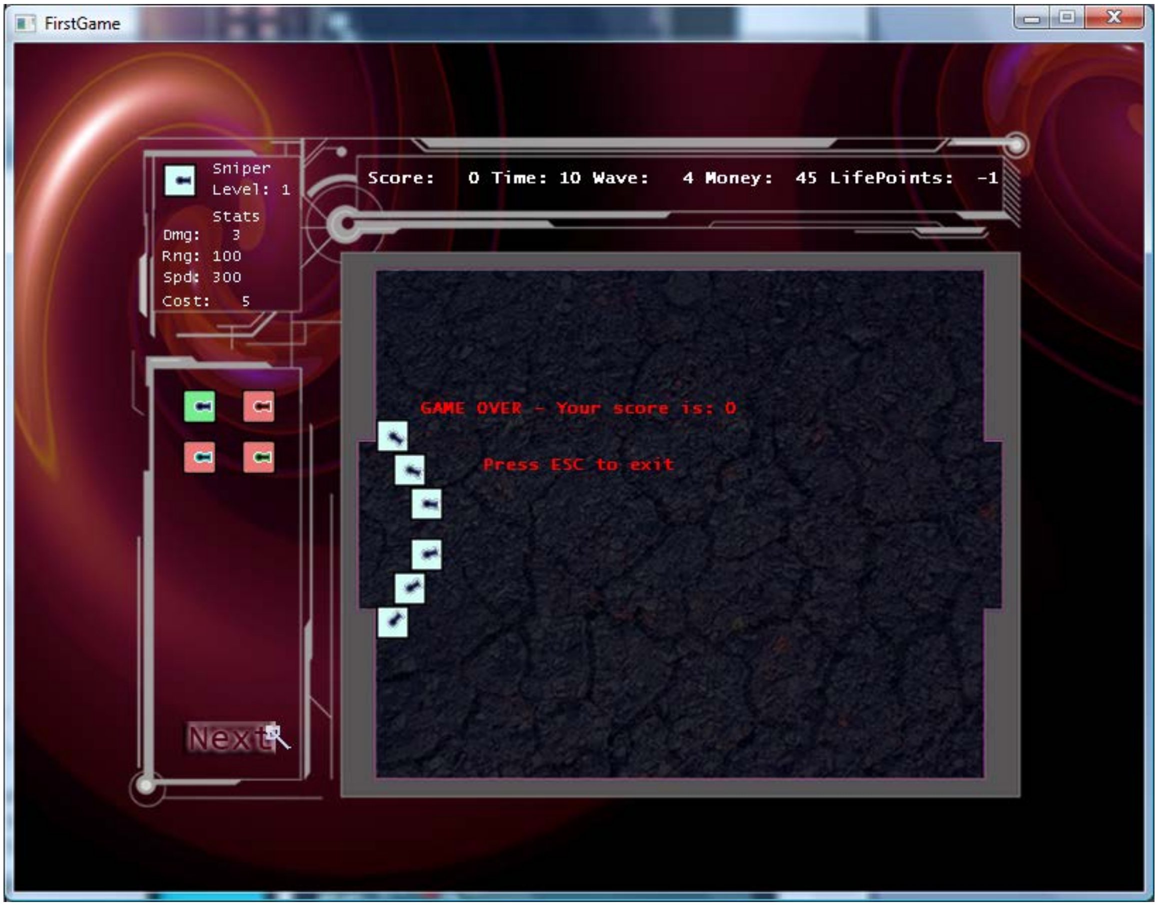


```
sniper
Level:1
       Cur Upg
Dmg:     3  10
Rng:   100 110
Spd:   300 300
Cost:   10

Score:   0 Time: 30 Wave:   3 Money:  45 LifePoints:   8
```

Figure 7: Screenshot showing player built towers shooting at monsters.

Since the player failed to destroy any monsters they have run out of life points and the game has ended in a loss, as can be seen in the following screenshot.



```
Sniper
Level: 1
Stats
Dmg:   3
Rng: 100
Spd: 300
Cost:   5
```

```
Score:   0 Time: 10 Wave:   4 Money:  45 LifePoints:  -1
```

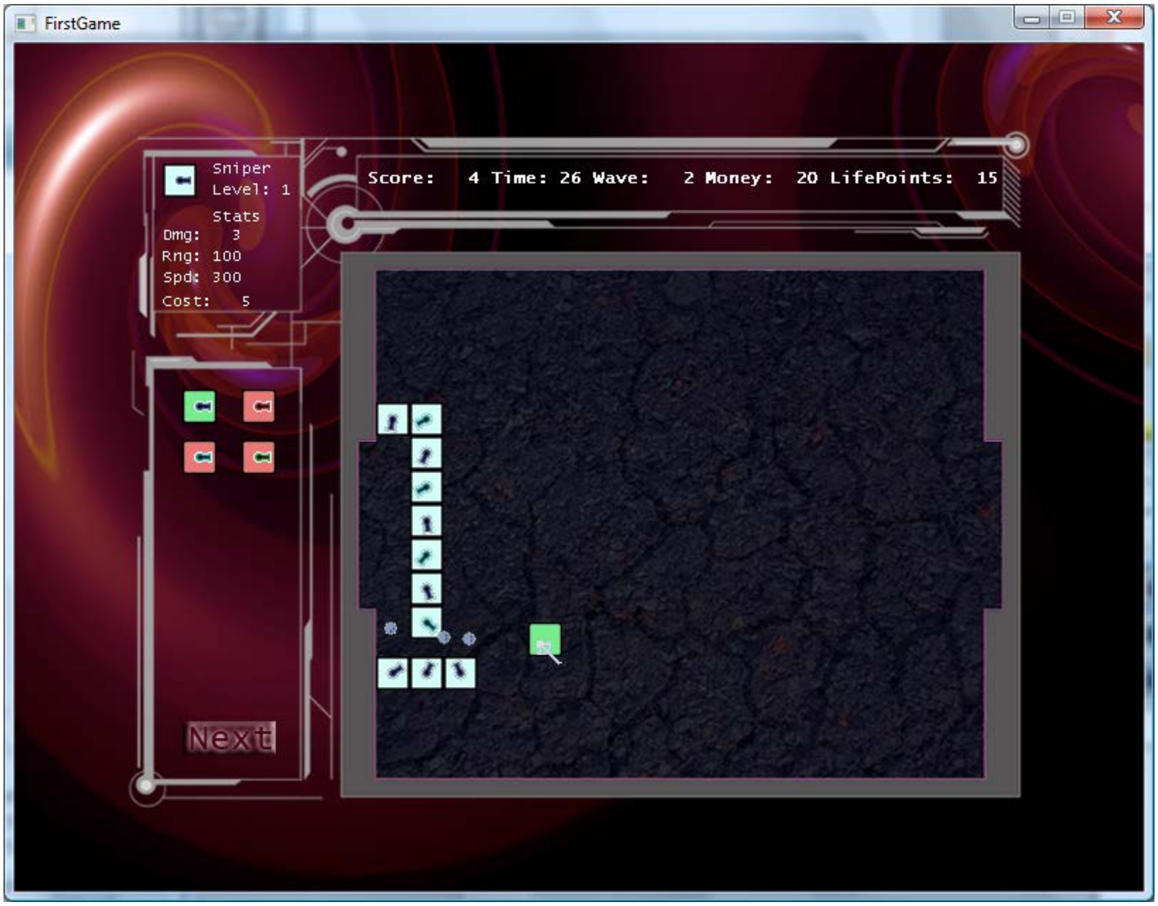
```
GAME OVER - Your score is: 0

Press ESC to exit
```

Figure 8: Screenshot showing the game over screen.

4.2 Advanced Play

Let’s try again only this time we will incorporate additional tower types and build them in a way which forces the monsters to follow elaborate paths. After rebooting the game the player has built some towers in a line forcing the monsters to move down, the player has also added a few plasma towers, which slow down monsters they attack. The player has already managed to kill 4 monsters and will finish off another one before the monsters can escape them. As seen in the following screenshot.

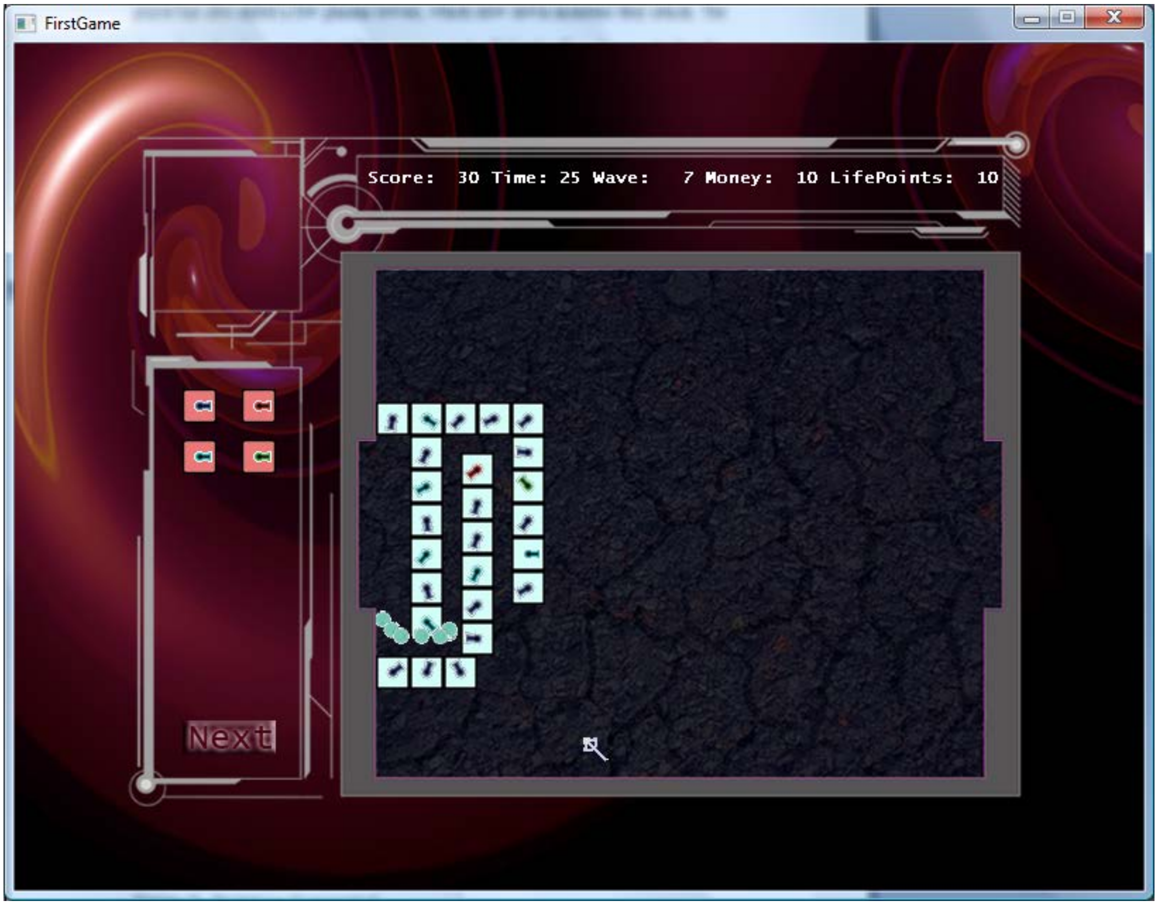


Sniper
Level: 1
Stats
Dmg: 3
Rng: 100
Spd: 300
Cost: 5

Score: 4 Time: 26 Wave: 2 Money: 20 LifePoints: 15

Figure 9: Screenshot showing a better maze with additional tower types.

Continuing through the game the player has added on to their maze, incorporating each kind of tower. Also the player is currently facing the “Tank” type of monster, which has massive amounts of LifePoints, but move very slowly. Let’s take a look at the status: The player has advanced to the seventh wave, lost 5 LifePoints and has a current score of 30. This is much better than our first attempt!



```
Score:  30 Time: 25 Wave:   7 Money:  10 LifePoints:  10
```

Figure 10: Screenshot showing an advanced maze and Tank monsters.

5. Testing Plan

The game is being tested alongside its development to ensure that it plays through as intended. I was responsible for all of the initial alpha testing. Once all of the common bugs were out and the game approached completion, tower and monster balance became a major issue. Therefore, I created a group page on the social networking website Facebook called “Rye-Wall Productions”. This group page hass all of the information needed to download, install, and then play the game. The group is open for anyone to join and currently has 29 members. From this group page the members are able to download the current build of the game to their computer and play through it. New game builds are still being published every few days. The group page also has a message board with questions about the game for the members to answer once they have played through it. Some sample questions might be “Did you find the game challenging?”, “Did you encounter any bugs?”, and “How was the game play? Did any portion seem clunky or forced?” The players answer them and the results are mailed to me. They are then reviewed and appropriate changes are made before the game is republished to the group page for further review. The game is still in production but I have submitted a Beta version to the XNA Community to be tested by other developers, as that is required for games being developed for the Xbox Marketplace.

6. Timeline

Table 1 which shows the project timeline: it shows what has been. The project is currently on schedule and pending approval of the XNA Community.

Table 1: Project Timeline

Week of	**Milestone Task**
Senior Design II	
1/5	Get Familiar with XNA Software/Tutorials
1/12	Construct basic images and build tower
1/19	Enable towers to fire bullets
1/26	Create monsters
2/2	Have towers aim and fire at monsters
2/9	Build reticule with selection
2/16	Build towers at reticule location
2/23	Monster movement around towers
3/2	Monster movement around towers
3/9	Reduce lag
3/16	Create final images/graphics, Finish game interface
3/23	Create additional towers/monsters
Senior Design III	
3/30	Create additional towers/monsters
4/6	Begin user/balance testing
4/13	Update changes, Continue testing
4/20	Update changes, Continue testing
4/27	Update changes, Continue testing, submit to XNA

7. Budget

The project budget has not changed much since Senior Design 1. The total cost of the project is still $360. I have all of the software and hardware needed to create the project. The only change since Senior Design 1 was the inclusion of Paint.Net instead of Gimp image editing software. However, Paint.Net is also free so it does not change the project budget. See Table 2 for budget details.

Table 2: Project Budget

Hardware / Software	Have / Need	Actual Cost	Spent
Xbox 360	Have	$200	$0
Xbox Live Membership	Have	$60	$0
XNA Game Studio Developer	Have	$100	$100
Microsoft Visual C# 2008 Express	Have	$19.99	Free with XNA
Audacity	Have	Free	Free
Paint.Net	Have	Free	Free
Total		Actual: $379.99	Spent: $100

7.1 Hardware

Xbox 360: The game console the game will be developed for.

PC: Computer for development and design.

7.2 Software

Windows XP Professional or Vista: Required for XNA game studio.

XNA Game Studio: Development Environment used for game creation.

Visual C# 2008 Express Edition: Programming Language used.

Microsoft Visual Studio .Net 2003: Development environment for C# code.

Paint.net: The games Graphics will be done in paint.net.

8. Conclusion

In conclusion, “Tower Defense” is a strategy game developed for the Xbox 360 Community Games Marketplace. The application was developed in C# in the XNA Framework. The project is nearing completion. It is still going through necessary balance and user testing. The only remaining hurdle is getting approval from the XNA Community. The game was submitted to the XNA Community on May 22, 2008 and is currently pending their approval.

Appendix A.
Code Snippets

A 1. Code Snippet for finding the monsters distance from destination

```
private static int distancefromend(int startX, int startY, int endX,
int endY)
        {
            float x = (endX - startX) * 10;
            float y = (endY - startY) * 10;

            float distance = (x * x) + (y * y);
            double temp = distance;
            temp = Convert.ToInt16(Math.Sqrt(distance));

            return Convert.ToInt16(temp);
        }
```

A 2. Code Snippet for finding the monsters position on the grid

```
private static string monsterposition(GameObject monster)
        {
            int Xspot = Convert.ToInt16(
            Math.Floor((monster.position.X - 256 + 8) / 12));
            int Yspot = Convert.ToInt32(
            Math.Floor((monster.position.Y - 172 + 16) / 12));
            return "Monster position X:" + Xspot + " Y:" + Yspot;
        }
```

A 3. Code Snippet for finding the angle the monster needs to face

```
private static float TurnToFace(Vector2 position, Vector2 faceThis)
        {
            float x = faceThis.X - position.X;
            float y = faceThis.Y - position.Y;

            float desiredAngle = (float)Math.Atan2(y, x);

            return desiredAngle;
        }
```

A 4. Code Snippet for updating sniper tower bullets

```
foreach (GameObject ball in bullets)
            {
                if (ball.alive)
                {
                    ball.position += ball.velocity;
                    if (!viewportRect.Contains(new Point(
                        (int)ball.position.X,
                        (int)ball.position.Y)))
                    {
                        ball.alive = false;
                        continue;
                    }
                    Rectangle bulletrect = new Rectangle(
                        (int)ball.position.X,
                        (int)ball.position.Y,
                        ball.sprite.Width, ball.sprite.Height);
                    foreach (GameObject enemy in enemies)
                    {
                        if (monsterWave >= enemy.wave)
                        {
                            Rectangle enemyrect = new Rectangle(
                                (int)enemy.position.X,
                                (int)enemy.position.Y,
                                 enemy.sprite.Width,
                                 enemy.sprite.Height);

                            if (bulletrect.Intersects(enemyrect))
                            {
                                enemy.totalHP = enemy.totalHP -
                               ball.damage;
                                ball.alive = false;
                                if (enemy.totalHP < 1)
                                {

                                    enemy.alive = false;
                                    score += 1;
                                }

                                break;
                            }
                        }

                    }
                }
            }
```

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