# COP290: 'Ping Pong'

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Our Desktop App, 'Ping-Pong' is a networked multi-player game played by two to four players. The players can be humans or can be backed by the computer.

The game involves players guarding their walls from the ball. If the ball touches the player's wall five times, the player is deemed as dead and the corresponding paddle is removed from the board. The player remaining alive till the very end is deemed as the winner.
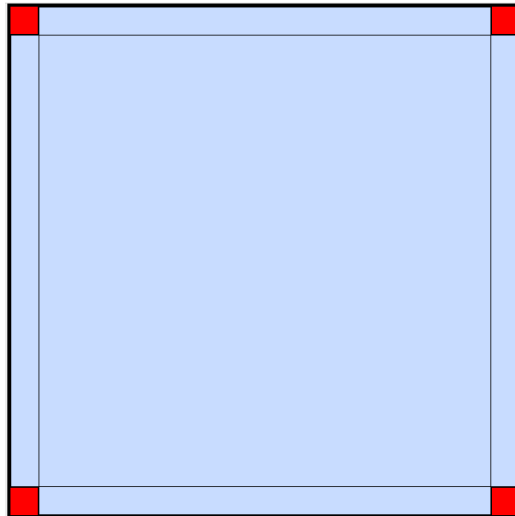


Figure 1: Game Board

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# 1 Scope of the Game

The basic design of the game has already been mentioned above. Following are the deviations the game offers to the players from it's basic design.

- **Ball Characteristics :** The characteristics of the ball (speed, size and number of balls) can be varied during the course of the game when the ball(or a ball in case of multiple balls) enters the dreaded *'WARP ZONE'.*~

  WARPZONE : The Warp Zone is a circular zone present at the center of the game board and is normally deactivated. It gets activated during the course of the game for some unknown mystical reasons for 10 seconds. When the (or a) ball enters the warp zone when it is activated, the ball experiences a change (either in speed, size or number) according to the colour of the warp zone and the warp zone gets deactivated.

  - **Red Coloured Warp Zone :** The ball increases it's speed by a factor of 2.
  - **Orange Coloured Warp Zone :** The ball decreases it's speed by a factor of 2.
  - **Yellow Coloured Warp Zone :** The ball increases it's radius by a factor of 2.
  - **Green Coloured Warp Zone :** The ball decreases it's radius by a factor of 2.
  - **Violet Coloured Warp Zone :** The ball splits into two balls i.e. two similar balls emerge out of the original ball.

- **Paddle Size :** Two kinds of coins can emerge from the center of the board at any moment of time. Green coin if caught by a paddle increases it's length while the red coin if caught by a paddle reduces it's length.

- **Special Powers of the paddle** Every paddle has a speed booster and a swing capability that can be unleashed at any moment of the game. This ability keeps on increasing till used after which it drops

down to zero. When this capability is unleashed, the ball emerges out at an increased speed from the paddle if the speed booster is unleashed and emerges out of the paddle swinging towards either left or right if the swing capability is unleashed. The ball returns to it's normal state (the original speed with no swing) once the ball touches another or the same paddle again or if the ball is missed by a paddle.

# 2 Physics of the game

Until the ball collides with a paddle, a wall of the board or with another ball in case of multiple balls, the ball always moves in a straight line with a constant speed unless it is explicitly made to swing either left or right by a player.

## 2.1 Motion of the ball under swing :

On being made to swing towards left (say), the ball moves as if there is a gravitational field towards left i.e. the ball experiences a constant acceleration towards left whose magnitude depends on the swing capability of the paddle. Thus the motion of the ball under swing can be expressed by a simple equation of 2-Dimensional projectile motion given by -

$$\frac{dx}{dt} = v_x - s \times t$$

$$\frac{dy}{dt} = v_y$$

where $x$ is directed towards right, $y$ is directed away from the paddle's wall perpendicular to it, $t$ is the time elapsed since contact with the paddle, $v_x$ and $v_y$ are the velocities of the ball towards $x$ and $y$ respectively when the ball left the paddle and $s$ is the magnitude of the swing. This equation is valid only till the ball suffers another collision (either with another ball, a paddle or wall after which the physics of impulse due to collision applies.)

If the ball is made to swing towards right, the ball moves as if there is a gravitational field towards right i.e. the ball experiences a constant acceleration towards right. The equation of motion of the ball in this case can be

expressed by the following equation of 2-Dimensional projectile motion.

$$\frac{dx}{dt} = v_x + s \times t$$

$$\frac{dy}{dt} = v_y$$

## 2.2 Ball Collisions :

### 2.2.1 Collision with another ball -

When the ball collides with another ball, both the balls are acted upon by an impulsive force according to the laws of physics observed in the physical 'real' world. The balls undergo the same momentum change in the direction of the line joining the centers of the two balls. The coefficient of restitution is assumed to be 1 and friction is assumed to be absent. The following are the equations for the collision. In these equations, only the motions along the line joining the centers of the two balls are considered as the motion in the tangential direction remains unaffected.

$$v_1^f = \frac{m_1 - m_2}{m_1 + m_2} v_1^i + \frac{2m_2}{m_1 + m_2} v_2^i$$

$$v_2^f = \frac{2m_2}{m_1 + m_2} v_1^i - \frac{m_1 - m_2}{m_1 + m_2} v_2^i$$

Here, $v_1^i$, $v_1^f$, $v_2^i$ and $v_2^f$ are the initial and final velocities of balls 1 and 2 respectively along the line joining the centers of the two balls towards each other while approaching and away from each other while receding. $m_1$ and $m_2$ are the masses of the balls. The mass is directly proportional to the square of the radii of the balls.

The above equations have been derived by the conservation of momentum and the conservation of Kinetic Energy (as the coefficient of restitution has been assumed to be 1.)

### 2.2.2 Collision with a wall -

When the ball collides with the wall, impulsive forces act according the laws of physics in the 'real' world in this case as well. The coefficient of restitution

is going to be assumed as 1 here as well. Hence, the angle of incidence will always equal the angle of reflection and the ball will continue traveling at the same speed.

### 2.2.3 Collision with a paddle -

This is the case where we have deviated from the laws of physics that apply in the actual physical 'real' world. We have done so with the intention to make the game a bit more interesting and to provide the player more control over the ball.

Instead of making the angle of incidence the same as the angle of reflection, we have provided the player an option to deviate the angle of reflection of the ball from the angle of incidence by making contact with the ball with the paddle away from the center of the paddle. The angle of deviation increases with the distance of the point of contact of the paddle with the ball from the center of the paddle. If the point of contact is towards the right side of the center of the paddle, the ball is deviated towards the right and vice-versa. There is no deviation if the ball makes contact with the center of the paddle i.e. the angle of incidence is equal to the angle of reflection if the ball makes contact with the center of the paddle.

# 3 Algorithm for the Computer Player

When one of the paddles is controlled by the computer instead of the human players, the computer is given the onus to guard it's wall from the ball and defeat all the human players. The game-play and strategy used by the computer to defeat all the human players is dependent on the difficulty level setting of the computer players.

## 3.1 Algorithm used by the computer players across different levels of difficulty

The computer can play across three levels of difficulty, namely 'easy', 'medium' and 'hard'.

Under the 'easy' setting, the paddle controlled by the computer blindly follows the current horizontal coordinate of the ball. This is clearly not at all an optimal strategy as the computer fails to make any predictions about the future movements of the ball by considering it's direction and swing. Also, the computer does not use the speed boosters and the swing capability that is given to it. Also, a small random noise is added to it's motion that is similar to the game of a novice human player who often gets confused and hence the motion of the corresponding paddle are randomized at times.

Under the 'hard' settings, the computer tries to predict the future movements of the ball and hence moves accordingly. It also makes an extensive use of the speed boosters and swing capabilities. It's game is focused on finding ways to defeat the human players and the use of random noise in it's motion is .

Under the 'medium' setting for the difficulty level, the paddle considers the current position of the ball along with the direction but ignores swing and hence is not very good at the prediction of the motion of the ball. It makes use of the speed boosters and swing capability but does not use them very intelligently with the prime focus of defeating human players. The use of random noise in it's motion is minimal but still present.

## 3.2 Dynamics of the computer player

As the network we are going to use is peer-to-peer, there is no central server and hence the computer player is run on the local hosts in a distributed fashion.

## 3.3 Events handled by the computer player

The computer player is required to predict the motion of the ball using the speed, direction and swing under the 'hard' setting of the difficulty level. This is really easy for the computer to compute as the trajectory of the ball is a completely deterministic function of the ball's radius, speed, direction and swing.

Another event that is required to be handled by the computer player is to judge the emergence and motion of the coins (green and red) and to run

towards them (generally in case of the green coins in order to increase the paddle length) or to run away from them (generally in case of the red coins in order to decrease the paddle length.)

This computation is made very efficient in case of the difficulty level settings being 'hard'.

# 4   Network Communication

## 4.1   Information exchanged between different machines

- Every machine will share its paddle co-ordinates with every other machine connected to it.

- Co-ordinates, velocity, direction, radius and swing of ball will be shared by the machine who last hit the ball with every machine connected till it gets hit by paddle of another machine then this machine will do the same.

- The information about warp zones must also be common on the various systems and hence must also be shared.

- Finally, the scores of all the players will be communicated to all the players.

## 4.2   Same game state seen by all the players

As all the variable information is shared by all the players, there is no reason why the game state should at all be different as seen by the different players.

We will try to refresh the connection as many times possible, let's say 20 times a second so that in every $1/20^{th}$ of a second new data will reach to every machine connected and game state will change accordingly in each machine.

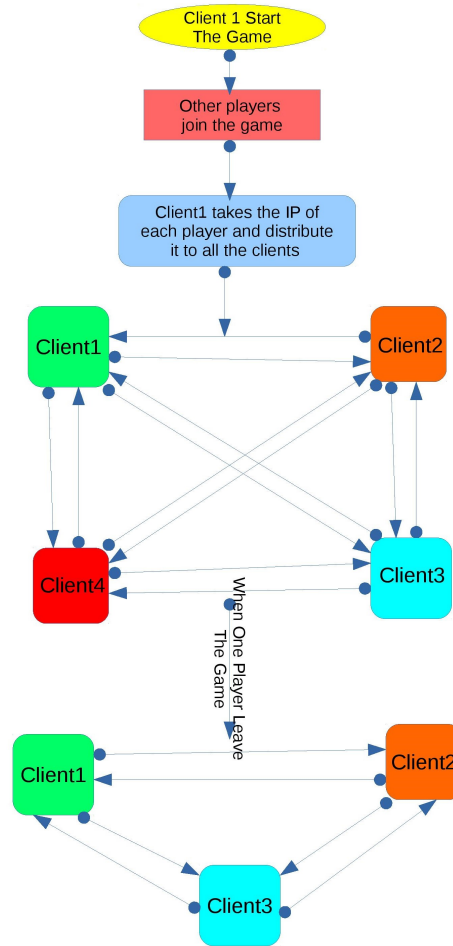## 4.3 Event flow for each network message



Figure 2: Event Flow

## 4.4 Trigger event to decide disconnectivity of player's machine

As our client to client connection (peer to peer) code is written in try catch so when a player points will exceed beyond a certain limit allowed or when anyone decides to quit the game, code will reach to catch where it will raise

exception.

This will be the trigger event, when exception will come in place of response, we will disconnect that machine and in place of that, computer will start playing at the very moment machine disconnects.

## 4.5 Action taken on a player's machine's disconnection from the network

When the code detects that a player's machine has been disconnected from the network, the computer plays in place of that player. The computer plays under the settings as specified at the beginning of the game.