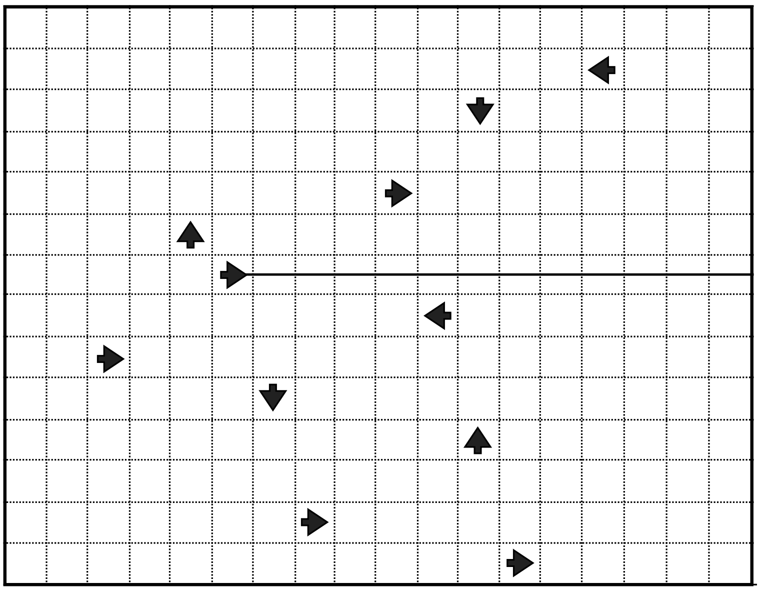
National University of Singapore
School of Computing

CS4344 **Problem Set 2: Interest Management** Semester 2 14/15

1. Consider the following multiplayer-player networked game, to be played within a large 2D game world consists of a grid of $k \times k$ cells. Each player controls a spaceship that occupies exactly one cell. A cell can only hold one spaceship at a time. A spaceship can face either up, down, left, or right. A spaceship can shoot a laser of *infinite* length in a straight line in the direction that it is facing, which would *immediately* damaged any spaceship that lies along the path of the laser. The *damage point* of a spaceship counts how many times the spaceship has been hit.

   The figure below shows a screenshot of the game, showing part of the game world. Each arrow represents a spaceship, facing in the same direction as the arrow. The figure shows one of the spaceship is shooting its laser.

   The objective of the game is to damage other players' spaceships as many times as possible. Players can issue three commands (*without any arguments*):

   - rotate - rotate the spaceship by 90 degrees clockwise.
   - move - move the spaceship forward by one cell in the direction that the spaceship is facing, when possible.
   - fire - shoot the laser immediately.

   An implementation of this game uses a permissable client/server architecture with short circuiting. It works as follow:

   - The states of the game consists of the position, direction, and damage point of each spaceship;
   - Each client maintains a local copy of the game states;
   - The server maintains the authorative copy of the game states;
   - Each command is simulated locally and sent to the server at the same time;
   - The server, upon receiving each command, simulates the game and sends the authorative states to each client;
   - If there is any inconsistency between the server's states and a client's states, the client will overwrite its own states with the server's states.

Suppose we want to implement interest management so that the server only sends every update from a player p to other players that are relevant to p. For players that are not relevant to p, the server sends p's updates to them at a lower frequency.

(a) Argue why both visibility-based interest management and distance-based interest management are not appropriate in this game.

(b) Suggest an alternative interest management scheme for this game. Specifically, explain how the server determines who are the players relevant to p.

2. Let C be the set of all cells in a game map and $PVS(c)$ ($\in C$) for a cell c be the set of all cells visible from c. A scheme is proposed to reduced the number of location update exchanges between two player A and B and it works as follows. Let c_A and c_B be the cells that A and B are in respectively. A computes $PVS(c_B)$ and B computes $PVS(c_A)$. Then as long as A is moving in a cell that belongs to $C - PVS(c_B)$, A needs not update B. Similarly, as long as B is moving in a cell that belongs to $C - PVS(c_A)$, B needs not update A.

   Is there anything wrong in this scheme? Explain.

3. Frontier set is a method to determine if two players should update each other in a peer-to-peer game and is based on cell-to-cell visibility – two players are to update each other if the cells that they are in are visibile from each other. Suppose we want to refine the definition of cell-to-cell visibility as follows: two cells X and Y are visible from each other only if there exist a point p_X in X and a point p_Y in Y such that (i) we can draw a straight line from p_X to p_Y without crossing any occlusion, and (ii) the distance between p_X and p_Y is less than d. Condition (ii) is the additional constraint that is not in the original frontier set scheme.

   Given this new constraint, describe the *changes* needed in computing the frontier set for any given two cells in the game.

4. In a game where players move in an open area with no occlusions, visibility-based interest management and frontier set are not suitable. In such scenario, distance-based interest management is more appropriate. Here, two players are interested in each other only if they are within distance d of each other. In this question, we change the definition of frontier set to the following so that it is suitable for distance-based interest management:

   A frontier of two points, p and q (on a 2D plane), consists of two regions (or, equivalently, two sets of points), F_{pq} and F_{qp}, such that any point in the region F_{pq} is not within distance d away from any point in region F_{qp}.

   Now consider two players, P and Q, whose initial positions are p and q respectively. If P and Q are of distance more than d apart, P can move anywhere within F_{pq} without needing to update Q, and Q can move anywhere within F_{qp} without needing to update P. We will refer to this new definition of frontier set as *frontier regions*.

   (a) Draw an example of frontier regions for two players P and Q who are more than distance d apart.

   (b) Unlike frontier set, frontier regions cannot be pre-computed offline as it depends on the positions of two players P and Q. Suggest how you can approximate F_{pq} and F_{qp} in such a way that an approximated frontier regions can be pre-computed offline.

5. One of the drawbacks of Voronoi Overlay Network (VON) is that players still occasionally exchange position updates even when they are not within the area of interest (AOI) of each other. Such scenario occurs because a player always connects to, and exchanges position updates with, its enclosing neighbors regardless of whether the enclosing neighbors are inside its AOI or not.

   (a) Explain why it could be useful for a player to exchange position updates with an enclosing neighbor that is outside of its AOI.

   (b) Consider two players A and B that use VON for interest management. A and B have the same AOI radius and their respective AOI overlaps. A and B, however, are not in each other's AOI.

      i. Is the following statement true? "If A and B do not have any common neighbor in their AOIs, then they must be enclosing neighbors of each other."
      Explain your answer with a diagram.

      ii. Is the following statement true? "If A and B are enclosing neighbors of each other, then they have no common neighbor in their AOIs."
      Explain your answer with a diagram.

6. Another drawback of Voronoi Overlay Network (VON) is that, in a crowded area within the game world, a player may need to maintain a large number of connections.

   Suggest how you can improve VON to handle crowded areas within the game world.