International Journal of Computational Intelligence Theory and Practice, Vol. 6, No. 1, June 2011

On Strategic Coordination

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Abstract: This paper outlines coordination among rational agents. Importance of common knowledge in achieving amicableoutcomesis explained. We highlight game theoretic coordination games as a class of strategic decision making protocols agents can apply during their communication.Temporal considerations including coordination graphs are also reviewed. For further elucidation, coordination components are put forward in an illustrating example in the context of American football.

Keywords: agents, collaboration, coordination, game theory

1. INTRODUCTION

By and large, collaboration mechanisms subsume cooperation and cooperation schemes subsume coordination (Hexmoor, *et al.*, 2006).Collaboration also subsumes role assignment protocols (Tuomela, 2000). Role assignment can benefit optimal distribution of tasks so as to maximize group benefit. However, role selectionalone does not typically specify simultaneous selection of tasks. For that matter time, role selection will not specifytemporal intricacies of role selections, which is central to strategic coordination. Among human activities, coordination involves extensive prior planning of actions and use of temporal trigger setting. For example, consider a commonplace example when there is a heavy or unwieldy box to be moved by several people, we might hear something like "on the count of three, push". In this example, participants have agreed to act in unison on a timing cue of hearing "three". When is this simultaneity of respective actions desirable? When there is a clear expected gainfor each and every coordination participant.Voluntarily participation is conditioned on anticipated marginal benefit even if this benefit is a modest share of a group benefit. Otherwise, self interested agents will be inclined to independently and privately cooperate with selected partnersabout specific interactions and mutually desirable outcomes. Dialectic communication for a subgroup coordination case will take place in private and subsequently they will make decisions that promote coordinationamong them. On the other hand, if every group member stands to benefit, all communication and information about actions and outcomeis often public. Strategic coordination involves simultaneous reasoning about choices for everybody by everybody.

Individual gains are best modeled in abstract terms of utilities (Fishburn, 1968). Roughly speaking, an agent's utility is its level of satisfaction experienced as a result of one or more of its decisions. An agent who is otherwise independent and makes decisions to maximize its utilities will consider coordination if joint decisions with others will increase its utilities more than by working alone. Decisions to publicly coordinate with others for the purposes of augmented utilities areat the core of *strategic coordination.* In common parlance, the concept of strategy has been used to describe military decisions. Game theory (GT) has adopted this term to describe utility maximizing decision makers. In the remainder of this paper, we rely in part on game theoretic developments.There is an important difference between strategic problems where agents act in their own interests, and non-strategic problems, where agents can be relied upon to follow rules given to them or to behave autonomously. In computer science, much of existing coordination research has centered on reasoning about plans and goals (Jennings, 1993), which does not directly concern itself with strategic reasoning. Nonstrategic coordination can also be found internal to an individual such as leg movements of a multi-legged mobile robot. No parallel reasoning (i.e., strategizing) is taking place on behalf of the robot legs. Instead, mobile robot design or robot control constraints produce coordination

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among the legs as a side effect. By generalization, structures in which individuals operate often provide partial or total ordering for the individual's strategies. Therefore, coordination in a highly structured environment is not a deliberate activity but rather a structural by product. Plans are common methods to codify implicit coordination. Implicit coordination in a group can be specified in plans that are either common knowledge or somehow shared.

In GT, a coordination gameis known as a common payoff or team game (Cooper,1998).Coordination game is broadly exploited across disciplines in social sciences, politics, and in economics (Gibbons, 1992). In computer science, GT motivations include the development of richer ways for modeling complex, modern problems of strategic interaction (Aumann, 1985). In political sciences, GT plays an important role for selecting decision making policies, which will yield the highest payoffs. It is often used for selecting the right person from a party as the leader for that party.

Every game with finite number of players and finite number of actions has atleast one Nash equilibrium (Harsanyi and Selton, 1988).Each coordination game has one or more Nash equilibria. Nash equilibrium can be defined as the solution, which gives the best payoff for the team or the individual.For an example of a generic coordination game, consider the 2-player, 2-strategy game, with payoff matrix in Figure 1. The entries in cells are utility values. A paired value x,y is joint payoffs for 1st player (i.e., the x value) and 2nd player (i.e., the y value) respectively.

	Up	*Down*
Up	A, a	C,c
Down	B,b	D,d

Figure 1: AGeneric 2 by 2 game

The game matrix in Figure 1 will depict a coordination game if and only if the following two conditions are met at the same time.

Condition 1: for player 1 (i.e., the row player):

$$A < B, \quad D < C \qquad (1)$$

Condition 2: for player 2 (i.e., the column player):

$$a > c, \quad d > b \qquad (2)$$

In the game of Figure 1, strategy pairs {A, a} and {D, d} are pure Nash equilibria. This is because in each of these pairs the first value is maximum value among its column values and the second value is the maximum value among its row values.

It is possible to considercoordination game for more than 2player settings. With three players, there would be nine possible combinations and corresponding number of payoff pairs. When we generalize to n players, there will be are n^2possible combinations and n^2payoff pairs. There will be numerous equilibria and a general scheme for selection among them is beyond our current scope.

	Party	Home
Party	x, y	0, 0
Home	0, 0	y, x

Figure 2: Battle of Sexes

Figure 2 depicts a coordination game that is commonly called*battle of sexes* (Osborne, Rubinstein, 1994). This game was originally motivated byplayers who are married or otherwise in a sexual relationship. Strictly speaking, sex is a metaphor and not a requirement for this game. The essence of the game is that players ought to select strategies that keep them together rather than apart. Player preferences differ over which activity they should pick be engaged. Whereas player 1 prefers that they both party, player 2 prefers that they both stay at home.

	Left	Right
Left	5, 5	0, 0
Right	0, 0	5, 5

Figure 3: Choosing sides

Another case for a coordination game is choosing the side of the road on which to drive. Consider two drivers driving on opposite lanes on a narrowtwo laneroad. When they meet, both have to swerve in order to avoid a head-on collision. If both carefully move to different sides they will manage to pass each other, but if they choose the same side they will collide. In the payoff matrix in Figure 3, "pass" is represented with a payoff value of 5, and "collide" by a payoff value of 0. A simple extension to n player is to repeatedly consider each agent playing against n-1 players. If the agent picks a strategy inconsistent with others, payoffs will be very low. On the other hand, if the agent complies with everyone else by choosing the same strategy, everyone comes out better off. An example of this is observing laws and conventions in a community. A small outlaw group can result in high social costs. An illustration of this is found in traffic laws in an urban environment (Lacey and Hexmoor, 2003).

	Stag	Hare
Stag	5, 5	0, 3
Hare	5, 0	3, 3

Figure 4: Stag Hunt

Figure 4 depicts the stag huntgame in which two huntersare out hunting together. They can benefit if they cooperate on hunting a stag (i.e., a relatively high prize with payoff of 5). However, cooperation fails, each hunter has an alternative, which is safer because it does not require cooperation to succeed for hunting a Hare (i.e., a relatively small prize with payoff of 3). A way to consider the problem in larger settings is when many people working on a monolithic problem (e.g., lifting a can yield the most payoff that is

	Party	Home
Party	10, 10	0, 0
Home	0, 0	5, 5

Figure 5: Pure Coordination Game

Pure coordination is the game where the players both prefer the same Nash equilibrium outcome. In the example shown in Figure 5, both players prefer partying over both staying at home.

People in computer science and game theory are interested in the prob-lem of co-ordination. In every field where the coordination is required researchers have found that in answer-ing these questions, it is useful to introduce formal ways of discussing what agents know.

2. EXOGENOUS EFFECTS AND INCENTIVES

In the real world, coordination is most often achieved by communication among players about combination of strategic selections to determine amicable agreements. This is exemplified by the ready stock of football *game plans* available ahead of any actual game. A game plan provides a detailed ordering among strategies and actions. It dictates player choices under a large set of conceived possibilities.*Side payment* is a method for a player to entice another to agree to a strategy combination in return for redeeming a portion of the expected payoff. Other forms of human enticement may involve coercions, coaxing, and threat, and blackmail. In social settings, countless other incentives such as peer pressure dominate decision making processes. However, there are no generic forms of these human centric incentives that can account for modeling computational strategic coordination.

Players might have innate tendencies (i.e., psychological traits) that affect their propensity toward coordination. *Agreeableness* is one of the fundamental traits that characterize individuals. Other than direct human modeling, it is not meaningful to ascribe such traits to computational processes. A form of this innate tendency was reported as the degree of cooperativeness in (Hexmoor, *et al.*, 2006). Combining preferences and performances of a group of agents, each agent's original preferences were adjusted according to its level of cooperativeness in order to increase performance for the whole group. Weaker players were compensated by stronger players via collaboration. Dynamic role reassignment component of collaboration can produce overall improved results. However, strategic agents cannot improve their coordination by this protocol. Any coordination benefit from role reassignments can be captured by temporal considerations such as with coordination graphs discussed in section 4.

3. COMMON KNOWLEDGE IN COORDINATION GAMES

Something is said to be *common knowledge*among a group of agents if all of them know it, all know that all know it, and recursively so on. Common knowledge turns out to be essential for coordination (Morris and Shin,1997). Common knowledge can be defined as special kind of knowledge for a group and agents of agents. There is common knowledge of p in a group of agents G when all the agents in G know p, they all know that they know p, they all know that they all know that they know p.

Consider thefollowing scenario that originally appeared in (Halpern and Tuttle, 1993).There are two divisions of an army, each headed by an independent general who is camped on one of two hilltops overlooking a valley. The commanding general of the first division has received an intelligence report informing him of the state of the enemy. It is clear that if the enemy is unprepared and both divisions attack the enemy simultaneously, they will win the battle, while if eitherenemy is prepared oronly one division attacks it will be defeated. If the first division general is informed that the enemy is unprepared, he will want to coordinate a simultaneous attack. However, the generals can communicate only by means of messengers. Unfortunately it is possible that a messenger will get lost or be captured by the enemy. It is necessary for at least one message to be delivered to the second division general from the first general in order for an attack to occur. The reason is that the second division general must be informed that the enemy is unprepared and also that they do not have a prior agreement on the timeto attack.

We would like to design both a communication protocol and action protocol, spec-ifying which general sends which message to the other in which circumstances intheir communication protocol, and an action protocolspecifying which general attacks in which circumstances.

These two protocols achieve coordinated attack withthe following three constraints.

(1) Attack never occurs when the enemy is prepared,
(2) If only one division attacks alone the mission cannot be fulfilled, and
(3) Both divisions should coordinate in order for a successful attack.

Coordination attack is not possible with unreliable communication. If the first general learns that the enemy is unprepared, he sends a message to the second general with the "attack" instruction. If the first message arrives, then the second general sends a messenger with a confirmation that the first message was received safely. If the acknowledgement is delivered without mishap, the first division general sends another message to the second division general informing him of this fact. On the other hand, if the second general never receives an instruction to attack, he cannot attack under any coordinated attack action protocol— it is possible that the first division general knows that the enemy is actually prepared and has not sent any messenger. Thus if the first division general never receives any confirmation of an instruction to attack, he will not attack: he thinks it possible that the second division general never received his message, and thus is not attacking. Even if one message is not delivered properly, coordinated attack cannot occur. This was one example of communication system. The possible result is that both generals should wait as long as all messages are received. Only then coordination attack can take place. Figures 6 and 7 summarize outcomes of decisions. If the attack was successful they have a payoff of 1 for generals. If the attack is unsuccessful that is either any one of the two generals attacked alone or enemy is preparedthey have a payoff of –M.If both generals decide not to attack, they will receive a payoff of 0.

General 1/General 2	Attack	Don't attack
Attack	-M,-M	-M, 0
Don't attack	0,-M	0, 0

Figure 6: Payoffs if the enemy is prepared

General 1/General 2	Attack	Don't attack
Attack	1,1	-M, 0
Don't attack	0,-M	0, 0

Figure 7: Payoffs if the enemy is unprepared

3.1. Temporal Considerations

In our coordination problem, let us assume that the messages are perfectly reliable but the transmission duration of a message is not known. Itmay arrive instantaneously or take T amount of time. At some point, the first general will receive his intelligence about the status of the enemy, and immediately send a message to the second general. This is the only message sent. If the enemy is unprepared, the generals would like to coordinate a simultaneous attack. But, the generals do not have synchronized clocks and they do not know whether the message took zeroduration or nonzero amountof time for the message to reach the second general. Each general gets a payoff of –M when only single general attacks. Payoff of 1 is received when both generals attack at the same time. Let us consider that the first general will plan on attacking Xtime after he hears that the enemy is unprepared while the second general willattack Ytime after he receives the message from the first general.

The first general expects the second general to attack Y time after receiving message. That is after waiting for Ytime after sending the original message, the first general gives probability 1/2 to the second general attacking, and 1/2 to his waiting another duration Z. Condition in equation 3 holds.

$$\frac{1}{2}*(-M)+\frac{1}{2}*(1)<0 \tag{3}$$

Due to the condition in equation 3,he will wait for $Y + Z$ time before attack.

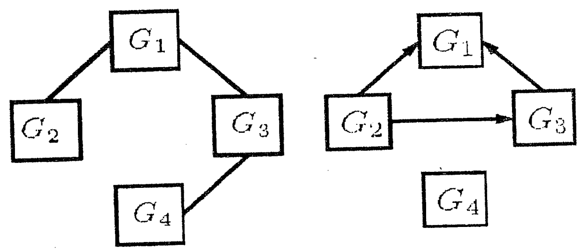
On the other hand, suppose the second general expects the first general to attack X seconds after sending his message.That is after waiting for X seconds after sending a message, the second general gives probability 1/2 to the second general attacking, and 1/ 2 to his waiting another duration Z. Once again, since equation 3 holds, he will for $Y + Z$ time before attack.

Our two generals are waiting for and durations respectively. Theywill not be able to find jointly stable, common waiting periods.This leads us to a need for approx-imate common knowledge in order to attain approximate coordinationthat relies on Bayesian accounts of knowledge and belief (Morris and Shin, 1997).

4. COORDINATION GRAPHS

A *coordination graph* represents the coordi-nation requirements for a system (Guestrin and Koller, 2002). The need for coordination graph arises when the number of joint actions grows exponentially with the num-ber of agents, making it infeasible to determine all possible equilibria in the case of many agents. This calls for methods that start by reducing the size of the joint action space before solving the coordination problem. One such approach is based on the use of a coordination graph that captures local coordination requirements among agents.

A node in the coordination graph represents an agent, while an edge in the graph depicts a dependency between two agents. Only interconnected agents have to coordi-nate their actions at any particular instance. Let us look at an example for a four agent problem. In this example, G2 has to coordinate with G1. G1 has to coordinate with both G2 and G3, G4 has to co-ordinate with G3, and G3 has to coordinate with both G4 and G1. The protocol assumes that each agent knows its neighbors in the graph but not necessarily their pay-ofi function, which might depend on other agents. Each agent is eliminated from the graph by solv-ing a local optimization problem that involves only one agent and its neighbors. The agent collects from its neighbors all possible payofi functions, then opti-mizes its decision depending on its neighbors' de-cisions, and communicates the resulting conditional payofi function back to its neighbors. A next agent is selected and the process continues. When all agents have been eliminated, each agent communicates its de-cision to its neighbors in the reverse elimination order in order for them to adjust their strategy. Consider the case where two individuals have to coordinate their actions to enter a nar-row doorway. We can describe this situation using the following value rule. This rule indicates that when the two agents are lo-cated in front of the same door and both select the same action that is entering the door; the agent payofi value will be reduced by 50. When the agents are not located in front of the same door, the rule does not apply and the agents do not have to coordinate their actions. For a more extensive example, see Figure 8b. The coordination dependencies between the agents are represented by directed edges, where each agent (i.e., child node) has an in-coming edge from the agent (i.e., parent node) that afiects its decision.



(a) An undirected graph (b) A directed graph

Figure 8: PrototypicalCoordination Graphs

5. AN EXAMPLE FROM THE GAME OF AMERICAN FOOTBALL

American football is a game of complex strategies and tactics (Schimanski, 2004). The basic strategy that each football team devises for a game is called a *game plan*, which has the best payoff. Each team possessthousands of diagramed plays and strategies that ispreparedprior toactual games for handling pre-determined situations and contingencies. During the game and at the half time break these strategies are considered in order to counter the opposing team's strategies. Often how well these adjustments are made will determine the outcome of the game. In any game we select the strategies with the best payoff from the list of available strategies.

In football, teams of eleven players have to fulfill a common goal for scoring more goals than their opponent. Depending on the current situation, certain agents on the playing field have to coordinate their actions. For exam-ple the agent that controls the ball must decide to which nearby agent to pass the ball and so on. Such dependencies can be modeled using coordination graphs that satisfy the following two requirements:

(i) Graph connectivity should be dynami-cally updated based on the current state.

(ii) Graph should be sparse in order to keep the dependen-cies and the associated local coordination problems as simple as possible.

For instance, one can easily identify several roles ranging from 'active' to 'passive' depending on whether an agent is in control of the ball or not. Given a particular local situation, each agent is assigned a role that is computed based on a role assignment function that is common knowledge among agents. The set of roles isfinite and ordered, so the most important role is assigned to an agent first followed by the second most important role and so on. By construction, the same role can be assigned to more than one agent, but each agent is assigned only a single role at a time.

For example, the goal for the defender is not to make the goal but to defend the opposing team players. Therefore, in a passive role the action of running is deactivated. Such a reduction of the action space can offer computational saving for the local coordination game. To accomplish coordination, all agents are first dynamically assigned a role based on the current state. First, we implemented a role assignment function that assigns the key roles of interceptor, passer, receiver, and passive among the agents using the continuous state information. The assignment of roles can be computed directly from the current state infor-mation.

All receiver roles are given to the agents that are inside a predefined field of the ball position. The remaining players are made passive. A com-mon situation is where the agent with the ball has the passer role, the three players that are in range of the passer are given the receiver role and the other players are made passive. This assignment of roles defines the structure of the coordination graph. All passers and receivers are connected. Note that this assignment changes dynamically as the state of the game changes. All connected agents have to coordinate their actions. For this, each agent can select one of the following actions:

(i) Move To(dir(heading)): move in the direction specified by heading.

(ii) Score: try to score in the opponent's goal zone

(iii) Run: Run with the ball with the aim of gaining the most yards

High level, information relevant for decision making are made available; e.g., Is-pass-blocked (i, j, dir) that indicates whether a pass from agent "i" to the position in direction dir of agent "j" is blocked by an opponent or not. Another example is Is-in-front-of-goal(j) that indicates whether the agent j is located in front of the opponent goal. As yet another indicator consider Is-empty-space(i, dir), which indicates that there are no op-ponents in direction dir of agent i. Is-pass(i,j,dir) indicates whether a pass from agent i to agent j in the direction of agent j.

5.1. Offensive Play

Each team has its own style of play and a strategy of how they like to play football. This strategy may be determined by the skill set of the players or the players may be chosen to fit into the strategy.

Some offensive football teams focus on the run. The offensive line will be chosen for their skills at run blocking. In a college option offense, even the quarterback will be foremost a runner and only a passer in long yardage situations. A run oriented offense is often called ball-control offense. By running, a team uses up time on the clock and also gives their defense a chance to rest. Running teams tend to turn the ball over less frequently and can keep the game to a lower score. Running football teams are good for using up clock when they have a lead, but have a more difficult time coming from behind.

Other offensive football teams focus on the pass. In this case the offensive line needs to be able to pass block. In this offense the tight end, running backs, and receivers are foremost skilled at catching passes. A pass oriented football team is usually formed around a great passing quarterback and his coordination. Passing teams are good at scoring quickly and making comebacks, but use up fewer clocks.

Most teams try to have balanced skill at both passing and rushing the football. It depends upon the coordination whether to go with passing or rushing, which ever captain think will yield the best payoff the team will follow that path. This balanced attack can keep the defense guessing and allows for more varied play calling depending on the game situation.

The heart of the football offense is made up of the offensive line. The main task for the offensive line is to block for the quarterback and running backs. This sounds simple, but offensive linemen must be prepared for all sorts of stunts and tricks thrown at them from the defense. They must also be able to stand and block for a pass play (i.e., pass blocking) or push the defense a certain way to create holes for a run play (i.e., run blocking). Offensive linemen run plays and move blocks around to fool the defense in order to keep defenders off of the players with the football. Offensive linemen tend to be big and strong. Without a strong offensive line, the rest of the football team will struggle.

An example of offensive play is shown in Figure 9.

In this offensive formation, we have 3 possible ways to beat the defense of the opposing team:

(i) The quarter back runs backwards. He has player 9 in his view. After he moves backwards, throws the ball to player 9 if 9is wide open (i.e., player 9's receiving the ball is safe).

(ii) If player 9 is not wide open, then the quarterback throws the ballup tothe offense group in his team.

(iii) The quarterback should run with the help of the offence line by keeping the adversary defensive people away from the quarter back's run.

Cases i and ii are passing the ball scenarios, whereas in case iii quarterback runs with the ball by penetrating the defense.

All three scenarios forovercoming defense are only possible with the aid of close coordination among players (offensive sub-team).But the best strategy among the three is that which has the highest payoff value for the team and also the player in the team.

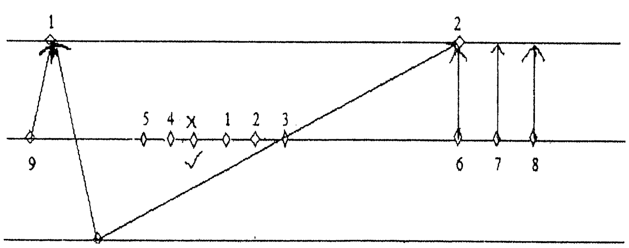


Figure 9: A Football Strategy Scenario

Next, we consider coordination graphs and common knowledge with our football example.

5.2. Common Knowledge

This type of knowledge is very important in football because all player in the offence team should know about the strategy which they are following at all times during the game. This is accomplished with the use of common knowledge.Even if one player in the team does not go with the strategy then coordination is not achieved and the desirable outcome is not obtained. For example if player 1 does not get the instruction and thinks of playing a different strategy then problem arises and the whole team coordination is disturbed because of the single player and if player 9 does not run the particular yards according to the plan then also coordination is disturbed. Everything should run according to the plan to achieve the best payoff.

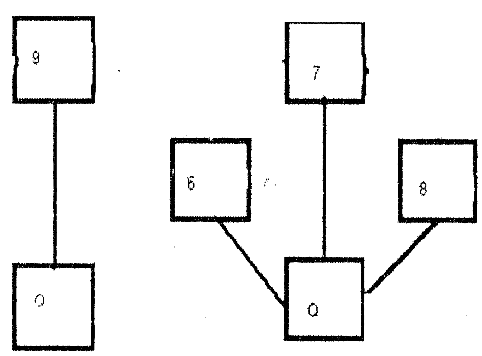
Is-pass (i, j, dir) indicates that a pass from agent i to agent j in thedirection of agent j.In this example Is-pass (Q,9 ,dir(9)) agent Q Should pass to the agent 9 in order to get the highest payoff.

5.3. Coordination Graphs

Figure 9 shows coordination graphs for two cases for our example in section 5:

Case 1: When the quarter back passes the ball to player 9 then coordination between the two player are active and rest of the players are in the passive mode.

Case 2: When the quarter back passes the ball to his offense group then coordination between the quarterback and the group are active and rest of players are in passive mode. The offensive group is composed of players numbered 6, 7, 8. Whichever player is available, quarterback will pass the ball to that player.



Case 1 **Case 2**

Figure 10: Examples for Coordination Graph in the Football Example

In this game we consider 2 strategic options, which we refer to as mixed strategies. A mixed strategy can be defined as an assignment of a probability to each pure strategy. This allows for a player to randomly select a pure strategy. Since probabilities are continuous, there are infinitely many mixed strategies available for a player, even if their strategy set is finite. Of course, one can regard a pure strategy as a degenerate case of a mixed strategy, in which that particular pure strategy is selected with probability 1 and every other strategy is given probability 0. Therefore, in this example of football the quarterback has three mixed strategies,he should decide with which one he should choose according to the highest probability strategy. But the quarterback should not always pick with the same strategy because the defense can predict the quarterback's game and might easily defend the offence team. Even if he has the best strategy, which has the payoff when compared with his other strategies, he should choosenot always choose the best.If herepeatedly and routinely picks a strategy, the defense can analyze the patterns and counteract the quarterback's plan.So there is no optimal strategy as such with mixed strategies.

The best way to win more yards is to change the strategy from time to time, by keeping the defense guessing. Next we further illustrate mixed strategies in a children's game.

5.4. Mixed Strategy with Rock, Paper, Scissors

In this section we will refer to the game of Rock, Paper, and Scissors (Sinervo andLively, 1996). In this game, there are 2 players who simultaneously determine which of three strategies to announce with their fingers. Each player has 3 strategies Rock, Paper, or Scissors. If both players pick the same strategy then they the outcome is a tie and they each receive 0. If one player picks a Rock and the other forms Scissors then the Rock player wins and receives 1, while Scissors player loses and receives a payoff of -1. If a player picks Scissors and the other picks Paper then Scissors wins and receives a payoff of 1 while Paper loses and receives a payoff -1. If a player picks Paper and the other forms Rock then Paper wins and receives a payoff of 1 and Rock loses and receives a payoff -1. In summary, Rock smashes Scissors, Scissors cut Paper, and Paper covers Rock.

Let player A play Rock with probability $q1$, Paper with probability $q2$, and Scissors with probability $1-q1-q2$. Player B plays his strategies with probabilities p1, p2 and 1 – p1 – p2.

When player B picks Rock the complementary probability for the player A that gives him the most payoff is shown in equation 4.

$$[(0 * q1) + (1 * q2) + (-1) * (1 - q1 - q2))] = 2q2 + q1 - 1 \tag{4}$$

Respective payoffs and probabilities are recordedin Figure 11.

Player B/ Player A	Rock	Paper	Scissors	q-mix
Rock	0, 0	-1, 1	1, -1	2q2 + q1–1
Paper	1,-1	0, 0	-1, 1	1 – 2q1 – q2
Scissors	-1, 1	1, -1	0, 0	q1 – q2
p-mix	2p2 + p1 – 1	1 – 2p1 – p2	p1 – p2	

Figure 11: Pay Offs

One could never rationally always choose Rock and have this choice be part of its equilibrium for the game. If one always chose Rock, then the opposing player would always choose Paper and would win every single time. But this cannot be a Nash equilibrium for the game, because if opposing player alwayschooses Paper, then the player who chooses Rock would want to switch to Scissors.From this example we can see that one should not always pick a strategy as its best strategy. If a player's strategy choice is static, the opposite player will pick a superior strategy to win more often.

6. CONCLUSION

Coordination is very important in many disciplines including computer science. In this paper,we reviewed coordination graphs, common knowledge, and game theoretic coordination. Our aim is to provide fundamental protocols for coordination as a form of cooperation that encapsulate simultaneous decision making such that joint payoffs are maximized. In order for a set of strategic agents to achieve their highest payoffs, they must strategically reason about decisions that can produce the most joint benefit. Using coordination graph will inform us which actors are in active state and which are in passive state. This will facilitate focus on active elements to achieve coordinate among them. Overall, coordination can only be achieved by giving all actors common knowledge in the game.By considering an example from American football we discussed the best way to coordinate in order to get the best payoff for the team and also the individuals in the game. Wehave argued thatusing a mixedstrategy is important in the long run for the coordination game and strategic coordination.

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