Lecture Slides Week #1
Game Theory Concepts

What is a Game?

- There are many types of games, board games, card games, video games, field games (e.g. football), etc.
- We focus on games where:
  - There are 2 or more *players*.
  - There is some choice of action where *strategy* matters.
  - The game has one or more *outcomes*, e.g. someone wins, someone loses.
  - The outcome depends on the strategies chosen by all players; there is *strategic interaction*.
- What does this rule out?
  - Games of pure chance, e.g. lotteries, slot machines. (Strategies don't matter).
  - Games without strategic interaction between players, e.g. Solitaire

Why Do Economists Study Games?

- Games are a convenient way in which to model the strategic interactions among economic agents.
- Many economic issues involve strategic interaction.
  - Behavior in imperfectly competitive markets, e.g. Coca-Cola versus Pepsi.
  - Behavior in auctions, e.g., bidders bidding against other bidders who have private valuations for the item.
  - Behavior in economic negotiations, e.g. trade negotiations.
- Game theory is not limited to economics!!

Four Elements of a Game:

1. The *players*
   - how many players are there?
   - does nature/chance play a role?
2. A complete description of the *strategies* of each player.
3. A complete description of the *information* available to players at each decision node.
4. A description of the *consequences (payoffs)* for each player for every possible profile of strategy choices of all players.

The Prisoners' Dilemma Game

- Two players, prisoners 1, 2. There is no physical evidence to convict either one, so the prosecutor seeks a confession.
- Each prisoner has two strategies.
  - Prisoner 1: Don't Confess, Confess
  - Prisoner 2: Don't Confess, Confess
  - Payoff consequences are quantified in prison years.
    - More years= worse payoffs.
  - Prisoner 1 payoff first, followed by professor 2 payoff.
- Information about strategies and payoffs is *complete*; both players (prisoners) know the available strategies and the payoffs from the intersection of all strategies.
- Strategies are chosen by the two Prisoners simultaneously and without communication.

Prisoners' Dilemma in "Normal" or "Strategic" Form

	Prisoner 2↓	
Prisoner 1↓	Don't Confess	Confess
Don't Confess	-1,-1	-15,0
Confess	0,-15	-5,-5

- Think of the payoffs as prison terms/years lost

How to play games using the comlabgames software.

- Double click on Comlabgames desktop icon.
- Click on ‘Client Play’ tab.
- Replace “localhost” with this address:

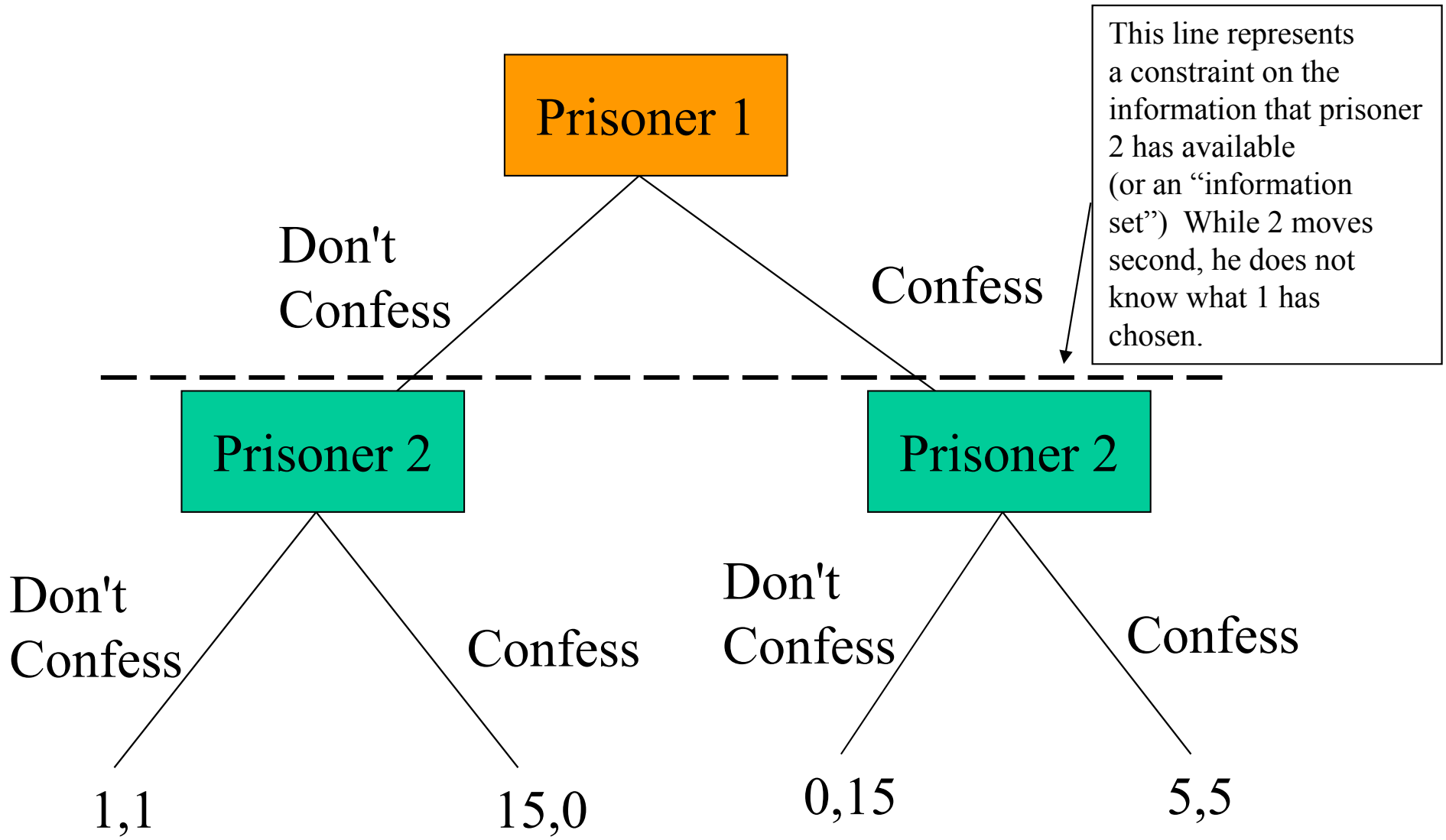
  136.142.72.19:9876

- Enter a user name and password (any will do). Then click the login button.
- Start playing when your role is assigned.
- You are randomly matched with one other player.
- Choose a row or column depending on your role.

Computer Screen View

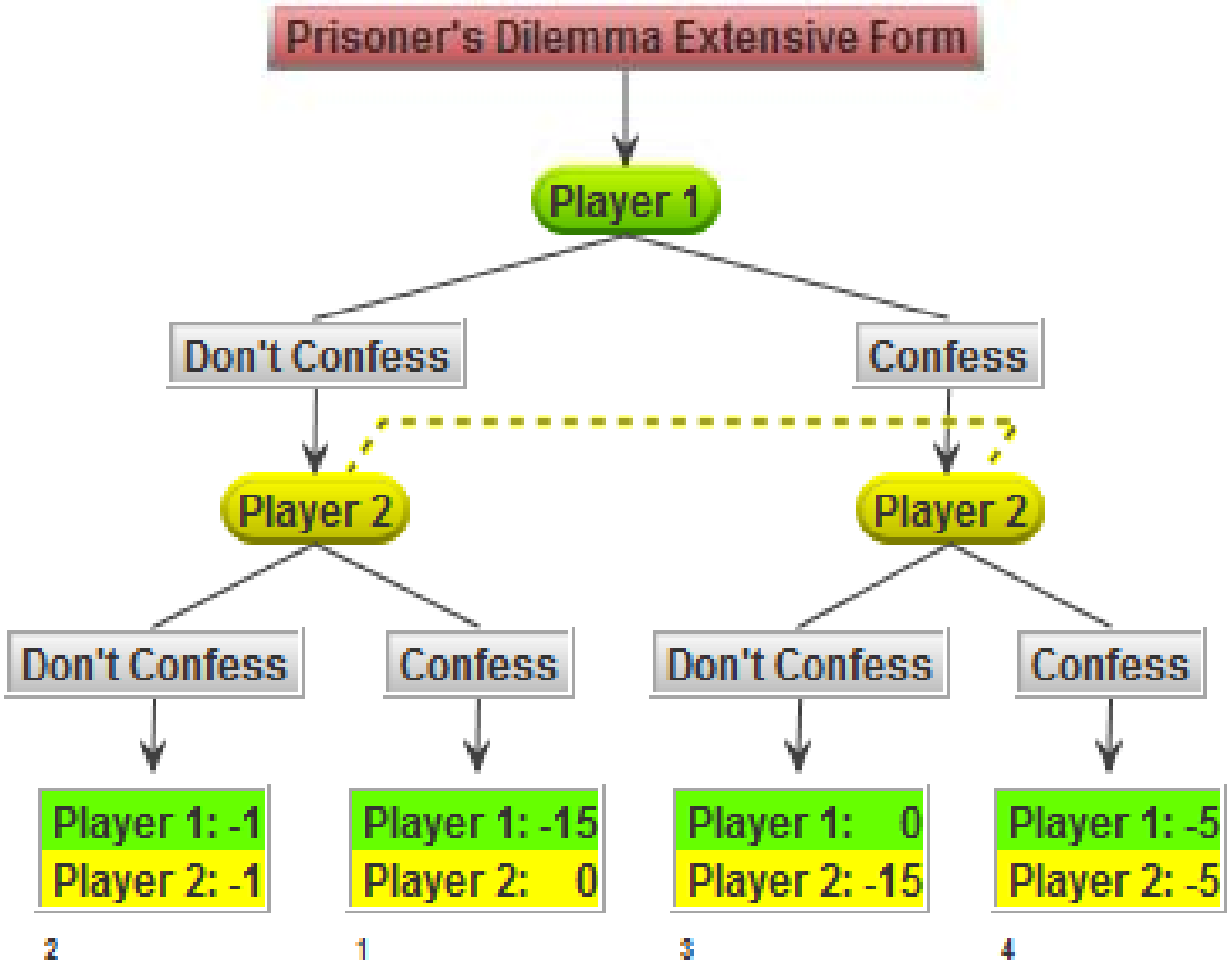
Results Screen View

Prisoners' Dilemma in "Extensive" Form



Payoffs are: Prisoner 1 payoff, Prisoner 2 payoff.

Computer Screen View



Prisoners' Dilemma is an example of a Non-Zero Sum Game

- A zero-sum game is one in which the players' interests are in direct conflict, e.g., in football, one team wins and the other loses.
- A game is non-zero sum, if players' interests are not always in direct conflict, so that there are opportunities for both to gain.
- For example, when both players choose Don't Confess in Prisoners' Dilemma, they both gain relative to both choosing Confess.

The Prisoners' Dilemma is applicable to many other situations.

- Nuclear arms races.
- Efforts to address global warming.
- Dispute Resolution and the decision to hire a lawyer.
- Corruption/political contributions between contractors and politicians.
- Can you think of other applications?

Can Communication Help?

- Suppose we recognize the Prisoner's Dilemma and we can talk to one another in advance, for instance, make promises to not confess.
- If these promises are non-binding and / or there are little consequences from breaking these promises (they are "cheap talk") then the ability of the prisoners to communicate prior to choosing their strategies may not matter.

Illustration of Problems with Cheap-Talk Collusion in the PD

- Dilbert cartoon
- Golden balls 1
- Golden ball1s 2

Golden Balls is not PD

- Steal is not a *strictly dominant* strategy.
- Consider the game in normal form:

		Player 2: Split	Player 2: Steal
Player 1	Split	50%, 50%	0%, 100%
	Steal	100%, 0%	0%, 0%

- If you think your opponent will steal, you are *indifferent* between stealing and splitting. Why? In that case, both strategies yield the same payoff, 0%.

The Volunteer's Dilemma: also has no dominant strategy

- A group of N people including you are standing on the riverbank and observe that a stranger is drowning in the treacherous river. Do you jump in to save the person or stay out?
- Suppose the game can be be assigned payoffs as follows:

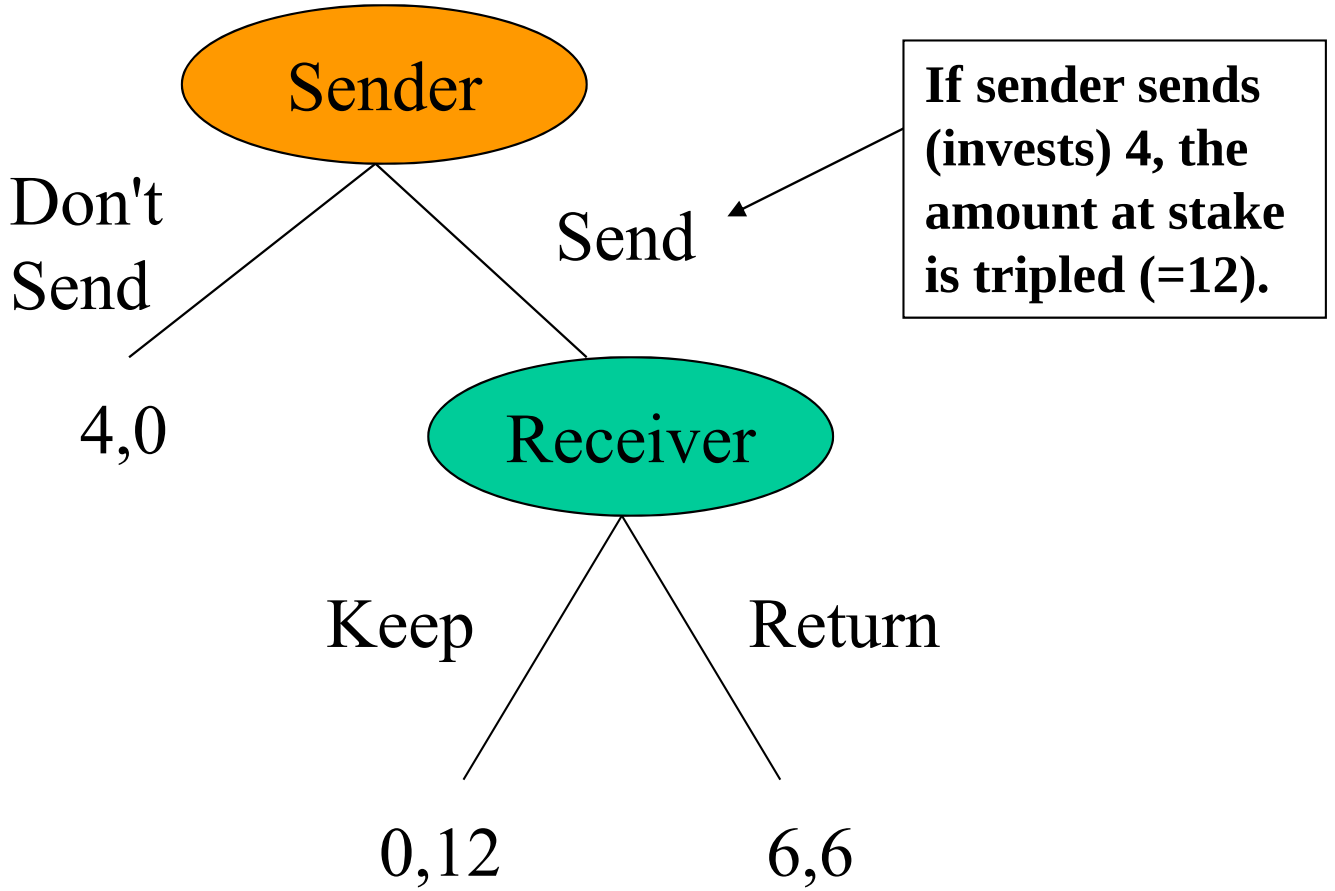
		N-1 others: Jump in River	N-1 others: Stay Out
You	Jump in River	0, 0	-1, 5
	Stay out	5, -1	-10 -10

- What is your strategy?

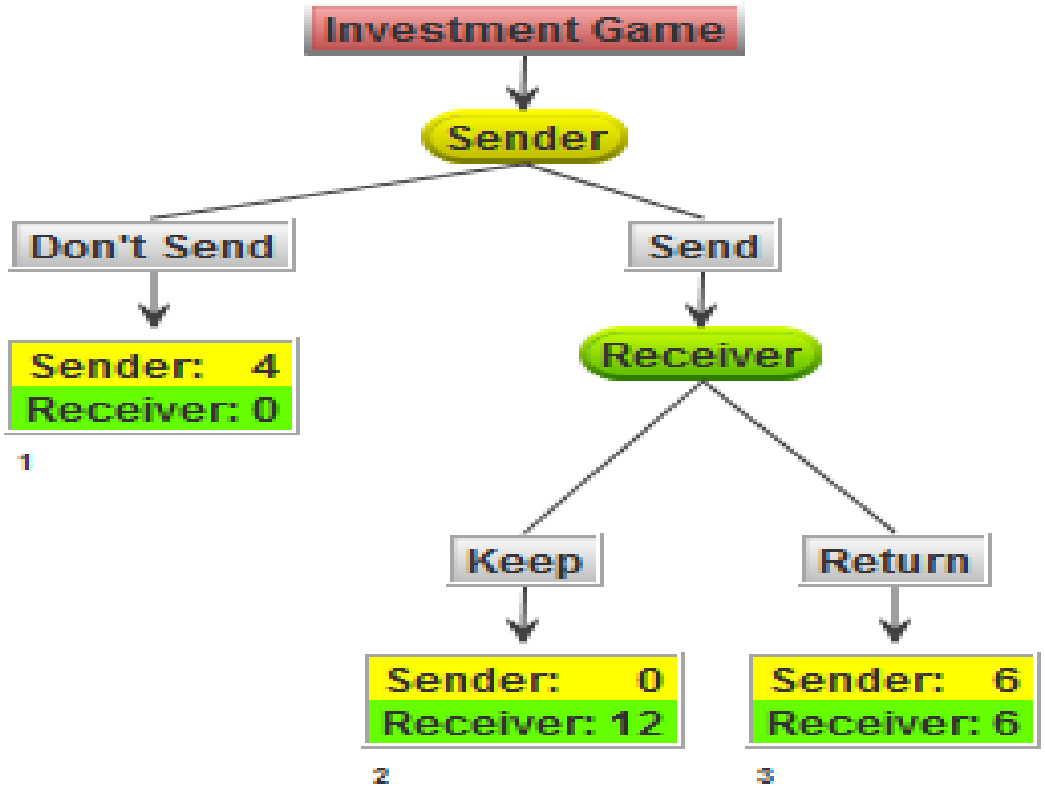
Simultaneous versus Sequential Move Games

- Games where players choose actions simultaneously are simultaneous move games.
  - Examples: Prisoners' Dilemma, Sealed-Bid Auctions.
  - Must anticipate what your opponent will do right now, recognizing that your opponent is doing the same.
- Games where players choose actions in a particular sequence are sequential move games.
  - Examples: Chess, Bargaining/Negotiations.
  - Must look ahead in order to know what action to choose now.
- Many strategic situations involve both sequential and simultaneous moves.

The Investment Game is a Sequential Move Game



Computer Screen View



- You are either the sender or the receiver. If you are the receiver, wait for the sender's decision.

One-Shot versus Repeated Games

- One-shot: play of the game occurs once.
  - Players likely to not know much about one another.
  - Example - tipping on your vacation
- Repeated: play of the game is repeated with the same players.
  - Indefinitely versus finitely repeated games
  - Reputational concerns matter; opportunities for cooperative behavior may arise.
- Advise: If you plan to pursue an *aggressive* strategy, ask yourself whether you are in a one-shot or in a repeated game. If a repeated game, *think again*.

Strategies

- A ***strategy*** must be a "comprehensive plan of action", a decision rule or set of instructions about which actions a player should take
- It is the equivalent of a memo, left behind when you go on vacation, that specifies the actions you want taken in every situation which could conceivably arise during your absence.
- Strategies will depend on whether the game is one-shot or repeated.
- ***Examples of one-shot strategies***
  - ***Prisoners' Dilemma:*** Don't Confess, Confess
  - ***Investment Game:***
    - Sender: Don't Send, Send
    - Receiver: Keep, Return
- How do strategies change when the game is repeated?

Repeated Game Strategies

- In repeated games, the sequential nature of the relationship allows for the adoption of strategies that are contingent on the actions chosen in previous plays of the game.
- Most contingent strategies are of the type known as "trigger" strategies.
- Example trigger strategies
  - In prisoners' dilemma: Initially play Don't confess. If your opponent plays Confess, then play Confess in the next round. If your opponent plays Don't confess, then play Don't confess in the next round. This is known as the "tit for tat" strategy.
  - In the investment game, if you are the sender: Initially play Send. Play Send as long as the receiver plays Return. If the receiver plays Keep, never play Send again. This is known as the "grim trigger" strategy.

Information

- Players have *perfect information* if they know exactly what has happened every time a decision needs to be made, e.g. in Chess.
- Otherwise, the game is one of *imperfect information*
  - Example: In the repeated investment game, the sender and receiver might be differentially informed about the investment outcome. For example, the receiver may know that the amount invested is always tripled, but the sender may not be aware of this fact.

Assumptions Game Theorists Make

- ✓ Payoffs are known and fixed. People treat *expected payoffs* the same as certain payoffs (they are *risk neutral*).
  - Example: a risk neutral person is indifferent between $25 for certain or a 25% chance of earning $100 and a 75% chance of earning 0.
  - We can relax this assumption to capture risk averse behavior.
- ✓ All players behave rationally.
  - They understand and seek to maximize their own payoffs.
  - They are flawless in calculating which actions will maximize their payoffs.
- ✓ The rules of the game are common knowledge:
  - Each player knows the set of players, strategies and payoffs from all possible combinations of strategies: call this information "X."
  - *Common knowledge* means that each player knows that all players know X, that all players know that all players know X, that all players know that all players know that all players know X and so on,..., *ad infinitum*.

What is Common Knowledge?

- Common knowledge means that everyone knows that everyone knows that everyone knows….
- Things that might be regarded as common knowledge:
  - Right/left hand side of the road
  - There are 7 days in a week.
- Things that may not be regarded as common knowledge:
  - Amount of fish caught by Philippine fishermen in 2010?
    - [290,000 metric tons]
  - The capital of Botswana?
    - [Gaborone]
  - Henry the VIII's third wife.
    - [Jane Seymour]
- Uncertainty of communication can mean a lack of comon knowledge, e.g. the email-game.

Equilibrium

- The interaction of all (rational) players' strategies results in an outcome that we call "equilibrium."
- In equilibrium, each player is playing the strategy that is a "best response" to the strategies of the other players. *No one has an incentive to change his strategy given the strategy choices of the others.*
- Equilibrium is not:
  - The best possible outcome. Equilibrium in the one-shot prisoners' dilemma is for both players to confess.
  - A situation where players always choose the same action. Sometimes equilibrium will involve changing action choices (known as a *mixed strategy* equilibrium).