Overview

- How do agents reach agreements when they are self-interested?

- In an extreme case (zero sum encounter) no agreement is possible — in most scenarios, there is potential for mutually beneficial agreement on matters of common interest.

The capabilities of: negotiation and argumentation are central to the ability of an agent to reach such agreements.

Two pictures that summarise negotiation:

1. Lose
2. Win
3. Other
4. Minimum

Voluntary Exchange Zone

http://www.csc.liv.ac.uk/~mjw/pubs/imas/
Mechanisms, Protocols, and Strategies

- Negotiation is governed by a particular mechanism or protocol.
- Negotiation often proceeds in a series of rounds, with proposals at every round.
- A rule that determines when a deal has been struck.
- Strategies: one for each agent, which are private.
- A protocol can make.
- A negotiation setting will have four components:
  - An negotiation set: possible proposals that agents can use.
  - A protocol.
  - Strategies, one for each agent, which are private.
  - A rule that determines when a deal has been struck.

One-to-one negotiation

Negotiation versus Auctions

- Auctions are only concerned with the allocation of goods. Agent strategies do not concern the goods.
- Negotiation is the process of reaching agreements on matters of common interest.
- Negotiation often proceeds in a series of rounds, with proposals at every round.
- A rule that determines what the agreement deal is.
- A protocol.
- A negotiation setting will have four components:
  - An negotiation set: possible proposals that agents can use.
  - A protocol.
  - Strategies, one for each agent, which are private.
  - A rule that determines when a deal has been struck.

Mechanisms, Protocols, and Strategies

- Proprieties like Pareto efficiency.
- They have certain describable properties.
- The mechanism defines the "rules of encounter" between agents.
- Given a particular protocol, how can a particular mechanism design be designed?

Chapter 15: An Introduction to Multiagent Systems 2e
Many-to-one negotiation

Many-to-many negotiation
• At the simple end there isn't much to distinguish
  – Many-to-one negotiation
  – Many-to-many negotiation

Negotiation for Resource Division

We will start by looking at Rubinstein's alternating offers model.

If not, we have round 1, and Agent 2 makes an offer.

If the offer is accepted, then the deal is implemented.

Agent 2 either accepts A or rejects R.

In round 1, Agent 1 makes an offer x(0). 

The rules of the protocol don't mean that agreement will ever be reached.

We make the following basic assumptions:

• A conflict deal Θ exists.

• If there is no agreement, we say the result is the conflict deal.

• Both agents prefer any agreement to none.

• Agents could just keep rejecting offers.

• Agents prefer to get larger utility values.

• Agents seek to maximise utility.

• Agents prefer to get larger utility values.

• Agreement is the worst outcome.

With this basic model, we get some odd results.

If there is no agreement, we say the result is the conflict deal Θ.
Let's assume that we will only have one round.

If Agent 1 proposes \((1,0)\), then this is still better for Agent 2 than the conflict deal. Agent 1 can do no better than this either. So we have a Nash equilibrium.

Model this as some resource with value 1, that is divided into two parts.

- Each part is between 0 and 1.
- The two parts sum to 1.

The set of possible deals is:
\[ \{(x, 1-x) : 0 \leq x \leq 1\} \]

If you are Agent 1, what do you offer?
A 1 round game is still an ultimatum game.

Now we can make some progress with the fixed number of rounds.

What if we have an indefinite number of rounds.

Let's say that Agent 1 uses this strategy:

Always propose (1, 0) and always reject any offer from Agent 2.

How should Agent 2 respond?

If she rejects, then there will never be agreement.

Always propose (1, 0) and always reject any other offer.

The closer \( \delta \) is to 1, the more patient the agent is.

Each agent has \( \delta_i \in [0, 1] \), where \( 0 \leq \delta < 1 \).

Discount the value of the outcome.

A standard way to model this impatience is to prefer \( x \) at time \( t_i \).

For any outcome \( x \) and times \( t_i \leq t_j \), both agents can get unique results if we take time into account.

Since we have an infinite number of Nash equilibria,

Impatient players

The solution concept of NE is too weak to help us.

In fact, whatever \( (x, 1 - x) \) agent 1 proposes here, agent 2 knows what agent 1's strategy is.

Immediate acceptance is the Nash equilibrium so long as agent 2 knows what agent 1's strategy is.

In fact, whatever \( (x, 1 - x) \) agent 1 proposes here, agent 2 knows what agent 1's strategy is.

So accept! And there is no point in not accepting on the first round.

Confict deal.

If she rejects, then there will never be agreement.

How should agent 2 respond?

What if we have an indefinite number of rounds?
We can see what these look like for buyers.

- Conceder
- Boulware
- Linear

Some common approximations:

A simpler approach is to use some heuristic thinking about the other player. The approach we just talked about relies on strategic

Heuristic approach

So this is now a Nash equilibrium.

- Then Agent 2 might as well accept — can do no better.

\[
\left( \frac{\varphi \psi - \varphi}{\varphi - \psi}, \frac{\varphi}{\varphi - \psi} \right)
\]

- If Agent 1 offers:

  - Agent 1 can take this into account.

  - Get the whole pie, but it is worth less.

  - But if so, will only get \( \varphi \).

  - 2 round game means Agent 2 can play as before.

A 2 round game means Agent 2 can play as before.

Note that the more patient either agent is, the more

\[
\frac{\psi \varphi - \psi}{(\varphi - \psi) \varphi}
\]

Agent 2 gets.

\[
\frac{\psi \varphi - \psi}{\varphi}
\]

Agent 1 gets.

In the second round, gives Agent 2 what Agent 2 would be able to enforce in the general case, Agent 1 makes the proposal that

Heuristic approach
Linear – Linear increase from initial price at the start time to the reserve price at the deadline.

Boulware – Very slow increase until close to the deadline and then an exponential increase.

Conceder – An exponential increase until close to deadline and then very slow increase.

An encounter is a collection of tasks.

\[ \langle T, A, C \rangle \]

where:

- \( T \) is the (finite) set of all possible tasks;
- \( A \) is the (finite) set of all participant agents;
- \( C \) defines the cost of executing each subset of tasks.

A task-oriented domain (TOD) is a triple:

\[ \langle T, A, C \rangle \]
Deals in $TOD$s

• Given encounter $\langle T_1, T_2 \rangle$, a deal will be an allocation of the tasks $T_1 \cup T_2$ to the agents $1$ and $2$.

• The cost to $i$ of deal $\delta = \langle D_1, D_2 \rangle$ is $c(D_i)$, and will be denoted $\text{cost}_i(\delta)$.

• The utility of deal $\delta$ to agent $i$: $\text{utility}_i(\delta) = c(T_i) - \text{cost}_i(\delta)$.

• Given encounter $\langle T_1, T_2 \rangle$, a deal will be an allocation of the tasks $T_1 \cap T_2$ to the agents $1$ and $2$.

The Negotiation Set

• Those that are:
  - individually rational: agents won’t be interested in deals that give negative utility since they will prefer the conflict deal.
  - Pareto efficient: agents can always transform a non-Pareto efficient deal into a Pareto efficient deal by making one agent happier and none of the others worse off.

The Negotiation Set Illustrated
An Introduction to Multiagent Systems

### The Monotonic Concession Protocol

Rules of this protocol are as follows:

- Negotiation proceeds in rounds.
- If no agreement is reached, then negotiation proceeds if the proposal from the negotiation set.
- On round 1, agents simultaneously propose a deal.
- Negotiation proceeds in rounds.
- If an agreement is reached, then negotiation proceedings.
- If no agreement is reached, then negotiation proceeds.

#### The Zeuthen Strategy

Three problems:

- What should an agent's first proposal be?
- On any given round, who should concede?
- If an agent concedes, then how much should it concede?

#### Willingness to Risk Conflict

Suppose you have conceded a lot. Then:

- Your proposal is now near the conflict deal.
- In case conflict occurs, you are not much worse off.
- You are more willing to risk conflict.

An agent will be more willing to risk conflict if the difference in utility between its current proposal and the conflict deal is low.
Nash Equilibrium Again...

The Zeuthen strategy is in Nash equilibrium: under the assumption that one agent is using the strategy the other can do no better than use it himself. The Zeuthen strategy is in Nash equilibrium under the assumption that one agent is using the strategy the other can do no better than use it himself.

This is of particular interest to the designer of automated agents. It does away with the need for secrecy on the part of the programmer. An agent's strategy can be publicly known, and no other agent can do no better than use it himself.

Deception in TDIS

Deception can benefit agents in two ways:

- Phantom and Decoy tasks
- Hidden tasks

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Summary

- This lecture has looked at different mechanisms for reaching agreement between agents.
- We started by looking at negotiation, where agents make concessions and explore tradeoffs.
- Finally, we looked at argumentation, which allows for more complex interactions and can be used for a range of tasks that include negotiation.