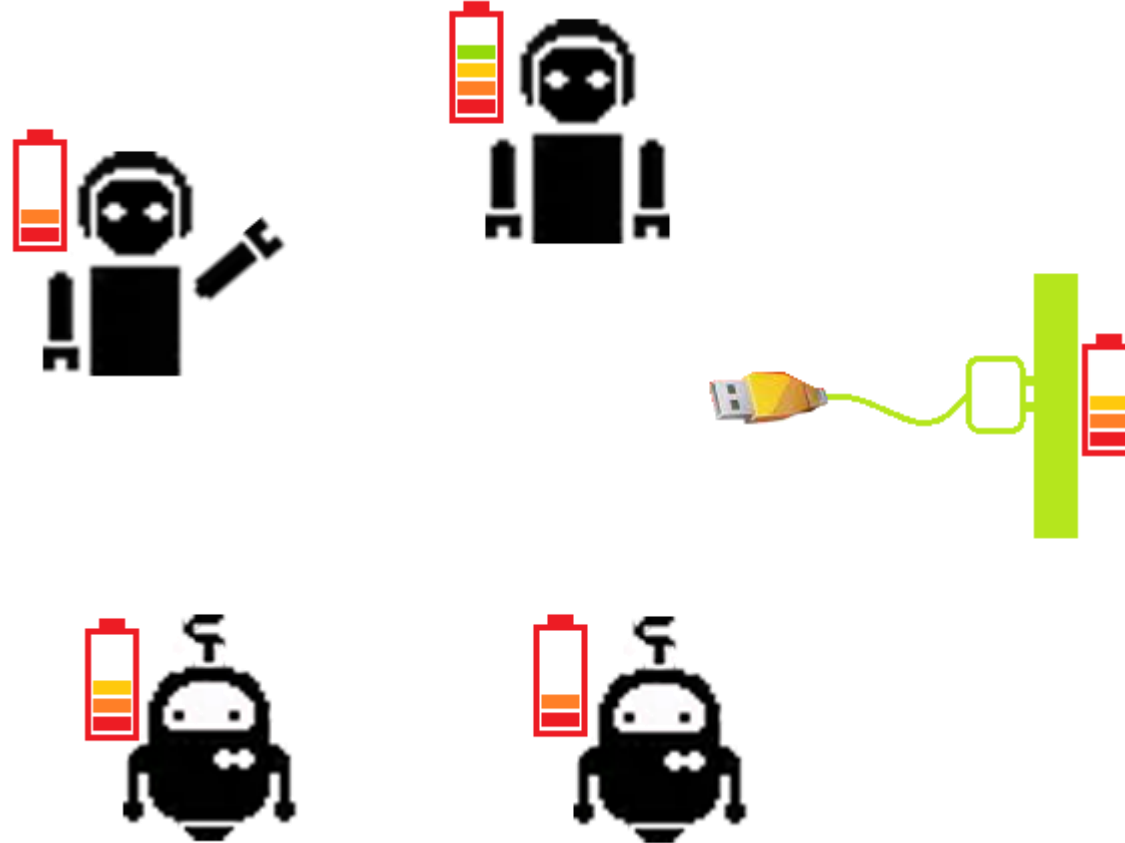


Negotiation and Bargaining

الدكتور محمد مصطفى السيد

- **Negotiation** is a form of *interaction*⁽¹⁾ in which a group of agents with *conflicting interests*⁽²⁾ try to come to a mutually *acceptable agreement*⁽³⁾ over some outcome.



Distributed Search Through A Space Of Potential Agreements

Aspects of Negotiation

1. The set of possible outcomes;
2. The agents conducting the negotiation;
3. The protocol according to which agents search for a specific agreement in this space;
4. The individual strategies that determine the agents' behavior, in light of their preferences over the outcomes.

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Negotiating over how to divide charge ?



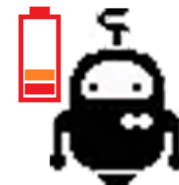
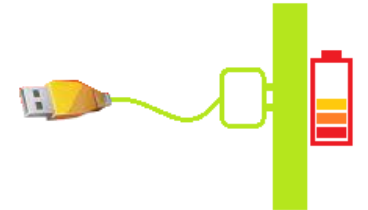
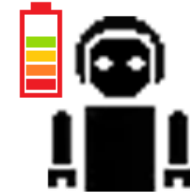
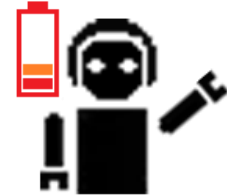
The set of possible outcomes;

- ***TASK-ORIENTED DOMAINS:*** domains involving the division of tasks to execute. agent preferences are measured in terms of the costs associated with different task allocations; each agent tries to minimize the cost of the tasks it has to execute.



The set of possible outcomes;

- *STATE-ORIENTED DOMAINS*: domains involving a joint decision about what state agents will achieve; agent preferences are over states that result from different deals; each agent tries to get to a more preferable state for itself.



- *WORTH-ORIENTED DOMAINS*: domains involving a joint decision about what goals to achieve; agent preferences are measured in terms of the number of individual goals each outcome achieves; each agent tries to achieve as many of its goals as possible.

The set of possible outcomes;

- \mathcal{O} is a space of possible *outcomes*.
- ψ of possible deals.
- *preference relation* \succsim_i of agent i over ψ .
- Preferences of agent i could be expressed as: $\mathcal{O}_1 \succsim_1 \mathcal{O}_2$.
- *Conflict deal*: agents do not reach an agreement in negotiation
- *Utility function* $U^i : \mathcal{O} \rightarrow \mathbb{R}^i$, which assigns a real number to each possible outcome.

$$\begin{aligned} &\because \mathcal{O}_1 \succsim_1 \mathcal{O}_2 \\ \therefore U^i(\mathcal{O}_1) &\geq U^i(\mathcal{O}_2) \end{aligned}$$

$$U^i = \sum_{k=1}^n w_k^i u_k^i$$

*Where W= weight and u: sub-utility function

Aspects of Negotiation

1. The set of possible outcomes;
2. The agents conducting the negotiation;
3. The protocols leading to which agent reaches from a specific agreement in the space.
 - One-to-one negotiation** One agent negotiates with just one other agent (symmetric preferences).
 - Many-to-one negotiation** In this setting, a single agent negotiates with a number of other agents (Auctions).
 - Many-to-many negotiation** In this setting, many agents negotiate with many other agents simultaneously.
4. The individual strategies that determine the agents' behavior, in light of their preferences.

$$\text{Negotiation threads} \Big|_{\text{many-to-many}} = \frac{n(n-1)}{2} \Big|_{\text{where } n:\text{no. of agents}}$$

Aspects of Negotiation

1. The set of possible outcomes;
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Game-Theoretic Approaches for Single-Issue Negotiation

1. Using *non-cooperative* game theory.
2. Using *cooperative* game theory.

Prisoners' dilemma
bridgeman
ART CULTURE HISTORY

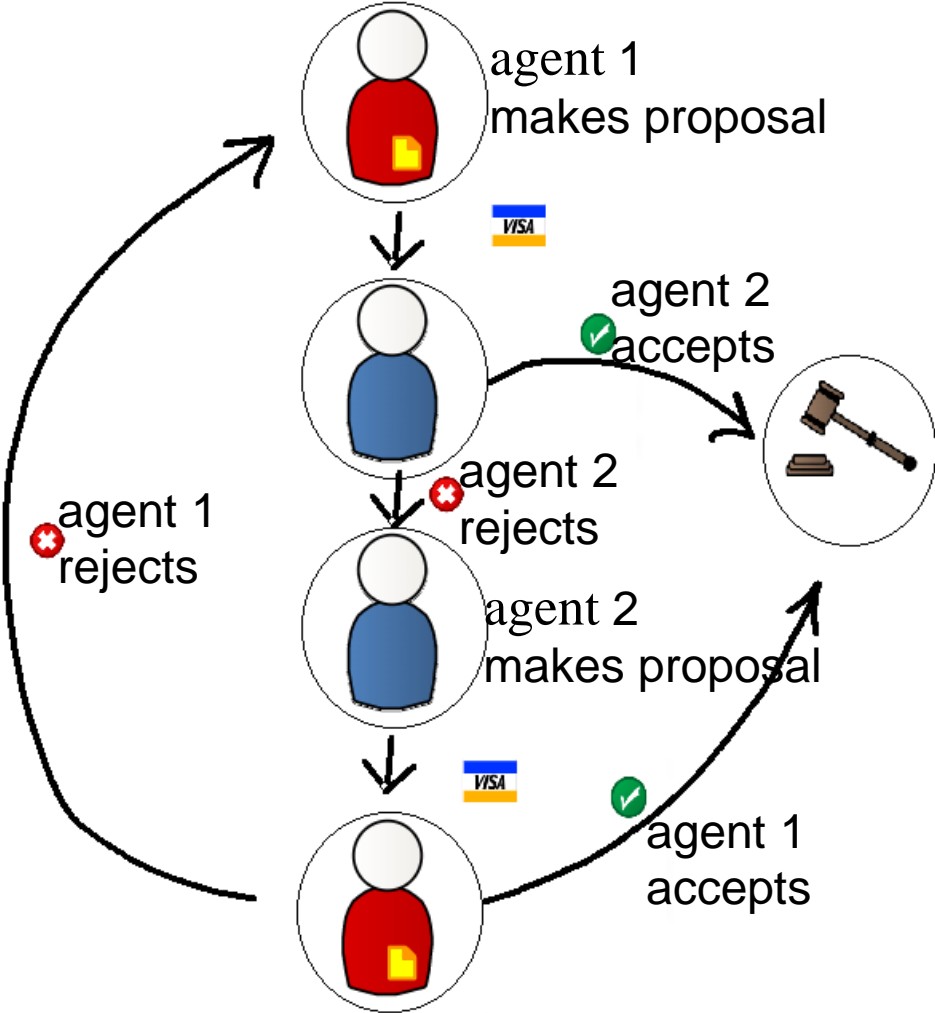
		prisoner B	
		confess	remain silent
prisoner A	confess	 5 years 5 years	 0 year 20 years
	remain silent	 20 years 0 year	 1 year 1 year

how the resource must be **divided** between them.

the preferences of the agents are **symmetric**,

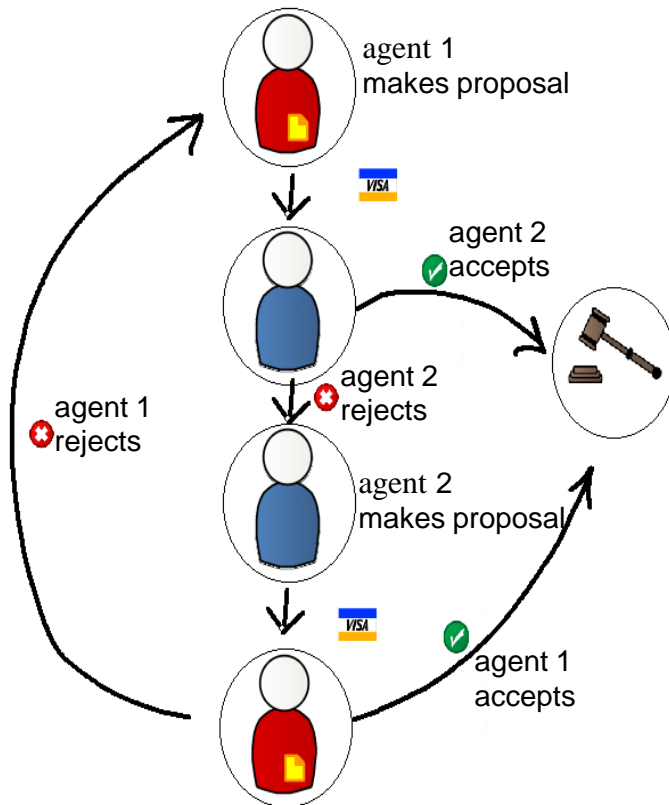


The alternating offers protocol



Ultimate game

- ❑ **Disagreement is the worst outcome** Both agents prefer any other outcome over disagreement.
- ❑ **Agents seek to maximize utility** Agents really do prefer to get larger utility values.



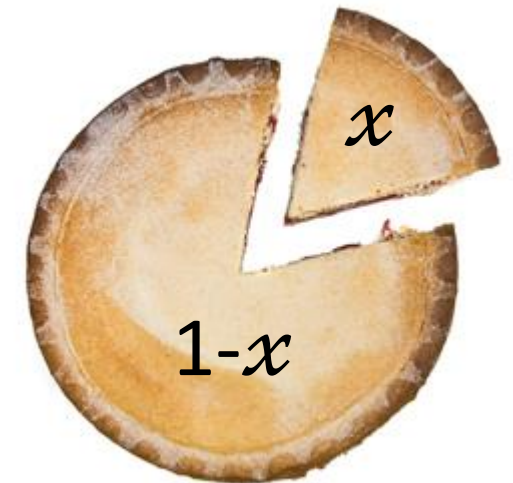
One round is allowed

agent 1 propose ($x=1$)
agent 2 rejects
agent 2 propose ($x=1$)
agent 1 have to accept to avoid *Conflict deal*

Many round is allowed

Ultimate game is the last round that push one agent to accept the least preferable outcome to avoid conflict deal .

$$\{(x, 1-x): 0 \leq x \leq 1\}$$



(dividing a pie)

Game-Theoretic Approaches for Multi-Issue Negotiation

Global bargaining: Here, the bargaining agents directly tackle the global problem in which all the issues are addressed at once.

Independent/separate bargaining: Here negotiations over the individual issues are totally separate and independent, with each having no effect on the other.

Sequential bargaining with independent implementation: Here the two parties consider one issue at a time. For instance, they may negotiate over the first issue, and after reaching an agreement on it, move on to negotiate the second, and so on.

Sequential bargaining with simultaneous implementation: This is similar to the previous case except that now an agreement on an issue does not take effect until an agreement is reached on all the subsequent issues.

